

## Appendix B

### The threats posed by the pet trade in alien terrestrial invertebrates in South Africa

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#### **Risk Analysis Report**

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|---|--|
| <b><i>Taxon:</i></b><br><i>Carausius morosus</i> (Sinety, 1901) | <b><i>Area:</i></b><br><b>South Africa</b> |
| <b>Compiled by:</b><br>Takalani Nelufule                        | <b>Approved by: ASRARP</b>                 |

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| <p><b>Picture of <i>Taxon</i></b> (G. Bradley – UK Safari)</p>    | <p><b>Alien distribution map</b> (GBIF, 2018)</p>  |
| <p><b>Risk Assessment summary:</b></p> <p><i>Carausius morosus</i> has already established a population outside of captivity in South Africa. It is found in gardens of the peri-urban areas of the southern peninsula of Cape Town and two other areas close by. This species is polyphagous and key biotic habitat conditions are met in a large part of the area. This species is also likely to find other parts of South Africa to be suitable as the main climatic requirements are met in a larger part (5-20%) of the area.</p> <p>Although, this species has been reported to be garden pest in San Diego and in South Africa, the species has minor socio-economic impacts.</p> <p>All the related species had minor environmental impacts caused through grazing, herbivory and browsing, but it is very uncertain whether this species would have these impacts in South Africa.</p> | <p><b>Risk score:</b></p> <p><b>High</b></p>   |
| <p><b>Management options summary:</b></p> <p>The area where the species has been reported to establish is not easily accessible because not all people will allow access to their gardens. Detectability of this species is critically time dependent, as they reproduce quickly and only takes 4-6 months to mature. Their egg takes up to six to eight months before hatching.</p> <p>There are reports that the species can be controlled using pesticides. The benefits of this species are low and the management of this species will require engaging property owners. Therefore, management of this species will be difficult.</p>   | <p><b>Ease of management:</b></p> <p><b>Difficult</b></p>  |

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| <p><b>Recommendations:</b></p> <p><i>C. morosus</i> is currently listed as category 1b and this report recommends that it is kept as category 1b. The species is already established in the country, has low benefits and would be difficult to manage. However, the whole order Phasmatodea is listed. It is not clear what the evidence for listing the whole order is, and this should at least be changed so that native species are explicitly excluded.</p> | <p><b>Listing under NEM:BA A&amp;IS lists of 2014 as amended 2016:</b></p> <p><b>1b</b> (as all Phasmatodea species (Jacobson &amp; Blanchi, 1902))</p> |
|   | <p><b>Recommended listing category:</b></p> <p>1b</p>   |

## 1. Background

| <b>BAC1 Name of assessor(s)</b>                                |   |
|--|---|
| Name of lead assessor  | <b>Takalani Nelufule</b>  |
| <b>BAC2 Contact details of assessor (s)</b>                    |   |
| Lead assessor  | Organisational affiliation: Department of Zoology and Entomology, University of Pretoria; South African National Biodiversity Institute |
|  | email: takalani.nelu@gmail.com  |
|  | Phone: 0765707034   |
| <b>BAC3 Name(s) and contact details of expert(s) consulted</b> |   |
| Expert (1)   | Name: Ed Backer   |
|  | email: edwbaker@gmail.com   |
|  | Phone:  |
| Expert (2)   | Name: Anonymous   |
|  | email: N/A  |
|  | Phone:  |
| Expert (3)   | Name: Nokuthula Mbanyana  |
|  | email: nmbanyana@iziko.org.za   |
|  | Phone:  |

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| Comments:   |                         |
| Expert (1): Edward Backer who is the assistant editor of phasmid species file, research associate at York University and works at the Natural History Museum in London, was consulted to find out more about impacts caused by <i>Carausius morosus</i> . His response was that this species causes minor socio-economic impacts. |                         |
| Expert (2): A breeder and a pet shop owner (who wished to remain anonymous) was consulted to find out if the species is still in the pet trade and their response was that "people are still breeding the species but might be afraid to come forward due to restrictions on selling this species."                               |                         |
| Expert (3): Works on the specimen database at the Iziko museum in Cape Town and provided the <i>C. morosus</i> accession number.  |                         |
| <b>BAC4 Scientific name of <i>Taxon</i> under assessment</b>  |                         |
| Taxon name: <i>Carausius morosus</i>  | Authority: Sinéty, 1901 |
| Comments: Binomial and taxonomic authority correct according to ITIS  |                         |
| References: <a href="https://www.itis.gov/">https://www.itis.gov/</a> accessed 18 July 2018.  |                         |
| <b>BAC5 Synonym(s) considered</b>   |                         |
| Synonyms: <i>Dixippus morosus</i> Sinéty, 1901  |                         |
| Comments: <i>Carausius morosus</i> was used to search for the synonym on ITIS   |                         |
| References: <a href="https://www.itis.gov/">https://www.itis.gov/</a> Accessed 18 July 2018.  |                         |
| <b>BAC6 Common name(s) considered</b>   |                         |
| Common names: Laboratory stick insect, Indian stick insect  |                         |
| Comments: India stick insect was used to search for other common names  |                         |
| References: <a href="https://www.gbif.org/">https://www.gbif.org/</a> Accessed 18 July 2018.  |                         |
| <b>BAC7 What is the native range of the <i>Taxon</i>?</b>   |                         |
| Response: India   | Confidence: High        |
| Comments: The confidence is high because according to the <i>Phasmida</i> species file, the species is native to India. Experts compile this database and leading specialists review the information in the database. Hence, the confidence is high.  |                         |
| References:<br><a href="http://phasmida.speciesfile.org/">http://phasmida.speciesfile.org/</a> Accessed 01 October 2018.  |                         |

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| <b>BAC8 What is the global alien range of the <i>Taxon</i>? (add map in Appendix BAC8)</b>   |                  |
| Response: Azores island; Faial Island; Madeira Island Portugal, South Africa and San Diego, USA  | Confidence: High |
| <p>Comments: The confidence is high because a number of references agree with these locations e.g. from Baker (2015) "There have many recent reports (2007) of the Indian Stick Insect (walking-stick) in the San Diego area, especially around Orange County. In April 2007 I contacted the San Diego Zoo, where Mike Bostwick carried out the Indian Walking Stick (IWS) Survey Project. This survey went from Oct, 2002 through July, 2005. In the last year IWS's were found but not in abundance and not recorded. Damage has been limited in the last year. A total of 38 individuals were recorded during that time and usually only one per entry on a specific host plant. There were also quite a large number of IWS found on host plant material in the Balboa Park area which is adjacent to the Zoo."</p>          |                  |
| <p>References:</p> <p>Aguiar, A. M. F., Pombo, D. A., &amp; Goncalves, Y. M. (2014). Identification, rearing, and distribution of stick insects of Madeira Island: an example of raising biodiversity awareness. <i>Journal of Insect Science</i>,14, 1-13.</p> <p>Borges, P. A. V., Reut, M., da Ponte, N. B., Quartau, J. A., Fletcher, M., Sousa, A. B., Pollet, M., Soares, A. O., Marcelino, J. A. P., Rego, C., &amp; Carodoso, P. (2013). New records of exotic spiders and stick insects to the Azores, and new data on recently introduced species. <i>Arquipelago</i>,30, 57-70.</p> <p>Brock, P. D. (1998). New records of alien stick insects. <i>Phasmid Study Group</i>, 7, 39-40.</p> <p>Baker, E. (2015). <i>Carausius morosus</i> introduced to San Diego. <i>Figshare</i>. doi:10.6084/m9.figshare.1304202</p> |                  |
| <b>BAC9 Geographic scope = the <i>Area</i> under consideration</b>   |                  |
| Area of assessment: South Africa   |                  |
| Comments:  |                  |
| <b>BAC10 Is the <i>Taxon</i> present in the <i>Area</i>?</b>   |                  |
| Response: Yes  | Confidence: High |
| <p>Comments: The confidence is high because the species have been reported to be established in the gardens of peri-urban areas of the southern peninsula and in Cape Town suburbs. The specimen was collected outside of captivity and is now available in the Iziko South African museum.</p>  |                  |

|   |     |                        |
|---|-----|------------------------|
| References:<br>Picker, M., & Griffiths, C. (2011). <i>Alien and invasive animals: A South African Perspective</i> . Cape Town: Struik.  |     |                        |
| <b>BAC11 Availability of physical specimen</b>  |     |                        |
| Response: Yes   |     | Confidence in ID: High |
| Herbarium or museum accession number: PHA-A000138; PHA-A000150; PHA-A000151 (Iziko Museum)  |     |                        |
| References: The Iziko South African Museum  |     |                        |
| <b>BAC12 Is the <i>Taxon</i> native to the <i>Area</i> or part of the <i>Area</i>?</b>  |     |                        |
| The <i>Taxon</i> is native to (part of) the <i>Area</i> .   | No  | Confidence: High       |
| The <i>Taxon</i> is alien in (part of) the <i>Area</i> .  | Yes | Confidence: High       |
| Comments: For justification of the confidence level, see BAC 7.   |     |                        |
| References:<br>Picker, M., Griffiths, C., & Weaving, A. (2002). <i>Field guide to insects of South Africa</i> . Cape Town: Struik.<br>Picker, M., & Griffiths, C. (2011). <i>Alien and invasive animals: A South African Perspective</i> . Cape Town: Struik. |     |                        |
| <b>BAC13 What is the <i>Taxon</i>'s introduction status in the <i>Area</i>?</b>   |     |                        |
| The <i>Taxon</i> is in cultivation/containment.   | Yes | Confidence: High       |
| The <i>Taxon</i> is present outside of cultivation/containment.   | Yes | Confidence: High       |
| The <i>Taxon</i> has established/naturalised.   | Yes | Confidence: High       |
| The <i>Taxon</i> is invasive.   | No  | Confidence: Medium     |

Comments: This species is known to be in captivity and is used as a pet and for laboratory purposes in South Africa (Picker & Griffiths, 2002). According to Picker & Griffiths (2002) and Brock (1998), *C. morosus* has been reported to have established a population in South Africa (in the suburbs of the Cape Peninsula). As this is one population, the species is not invasive. However, the extent of the invasion is not known (Picker & Griffiths, 2011). As there is evidence that the species is kept in containment and has established a population, confidence in these assessments is high, but as the full extent of the invasion is uncertain, confidence in whether the species is invasive is medium. Future studies should be directed towards understanding *C. morosus* behaviour in their introduced range in South Africa.

References:

Brock, P. D. (1998). New records of alien stick insects. *Phasmid Study Group*,;7, 39-40.

Picker, M., Griffiths, C., & Weaving, A. (2002). *Field guide to insects of South Africa*. Cape Town: Struik.

Picker, M., & Griffiths, C. (2011). *Alien and invasive animals: A South African Perspective*. Cape Town: Struik.

**BAC14 Primary (introduction) pathways**

|             |                  |                    |
|-------------|------------------|--------------------|
| Release     | Yes              | Confidence: Medium |
| Escape      | Yes (Pet escape) | Confidence: Medium |
| Contaminant | No               | Confidence: High   |
| Stowaway    | No               | Confidence: High   |
| Corridor    | No               | Confidence: High   |
| Unaided     | No               | Confidence: High   |

Comments: It is not known whether this was an accidental release or deliberate introduction (Brock 1998), hence, the confidence is medium.

It is likely that the stock originated from specimens being reared by Le Feuvre (1936), who published a useful account of the two native species found in the Cape Suburbs (*Macynia labiata* (Thunberg) and *Phalces longiscaphus* (de Haan)). This species is known to have been introduced for laboratory use and as pets.

References:

Brock, P. D. (1998). New records of alien stick insects. *Phasmid Study Group*, 7, 39-40.

Picker, M., Griffiths, C., & Weaving, A. (2002). Field guide to insects of South Africa. Cape Town: Struik.

## 2. Likelihood

| LIK1 Likelihood of entry via unaided primary pathways   |                  |
|---|------------------|
| Response: 1   | Confidence: High |
| <p>Rationale: The species has been reported to be established in South Africa (so response is 1).</p> <p>This species is not known to be present in South Africa's neighbouring countries so it very unlikely that this species could arrive unaided in South Africa in future. The confidence is high because there is enough evidence from literature that agree with this information.</p> |                  |
| References:   |                  |
| Brock, P. D. (1998). New records of alien stick insects. <i>Phasmid Study Group</i> , 7, 39-40.   |                  |

| LIK2 Likelihood of entry via human aided primary pathways  |                    |
|--|--------------------|
| Response: 1  | Confidence: Medium |
| <p>Rationale: The species has been reported to be established in South Africa (so response is 1).</p> <p>This species is used as a pet. Other stick insects have been observed in the South African pet trade, e.g. Australian stick insect (<i>Extatosoma tiaratum</i>). Therefore, many people might still be keeping the stick insects as pets and they are likely to move the species around.</p> <p>The species is likely to be kept as suggested by an expert but we haven't seen that the species is still kept hence the confidence is medium.</p> |                    |
| References:  |                    |
| Aguiar, A. M., F, Pombo, D. A., & Gonçalves, Y. M. (2014). Identification, rearing, and distribution of stick insects of Madeira Island: An example of raising biodiversity awareness. <i>Journal of Insect Science</i> , 14, 49.  |                    |
| Picker, M., Griffiths, C., & Weaving, A. (2002). <i>Field guide to insects of South Africa</i> . Cape Town: Struik.  |                    |
| Picker, M., & Griffiths, C. (2011). <i>Alien and invasive animals: A South African Perspective</i> . Cape Town: Struik.  |                    |

| LIK3 Habitat suitability |
|--------------------------|
|--------------------------|

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|--|--------------------|
| Response: Probable   | Confidence: Medium |
| <p>Rationale: <i>Carausis morosus</i> and other related species are polyphagous and can feed on a large number of plants which makes this group suitable for South African habitat, especially the Cape Floristic Region, where plant diversity is high.</p> <p><i>C. morosus</i> is probably very widespread on many food-plants in the Cape Suburbs, both in gardens and in the fynbos areas (though this needs to be confirmed) (Brock, 1998). All key biotic habitat conditions are therefore, met in a large part of the area.</p> <p>Confidence is medium because this species is known to be polyphagous, but in South Africa, it is not clear which tree species they prefer (Brock, 1998).</p>  |                    |
| <p>References:</p> <p>Borges, P. A. V., Reut, M, da Ponte N. B., Quartau, J. A, Fletcher, M., Sousa, A. B., Pollet, M., Soares, A. O., Marcelino, J. A. P., Rego, C., &amp; Carodoso, P. (2013). New records of exotic spiders and stick insects to the Azores, and new data on recently introduced species. <i>Arquipelago. Life and Marine Science</i>, 30, 57-70.</p> <p>Brock, P. D. (1998). New records of alien stick insects. <i>Phasmid Study Group</i>, 7, 39-40.</p> <p>Metzger, M. J., Bunce, R. G. H., Jongman, R. H. G., Sayre, R., Trabucco, A., &amp; Zomer, R. (2013). A high-resolution bioclimate map of the world: A unifying framework for global biodiversity research and monitoring. <i>Global Ecology and Biogeography</i>, 22, 630–638.</p> |                    |

| <b>LIK4 Climate suitability</b>  |                    |
|--|--------------------|
| Response: Fairly probable  | Confidence: Medium |
| <p>Rationale: No formal modelling has been done for the species, however based on the Koeppen-Geiger climate zones, the climate in the species' native range in India is similar to parts of South Africa (see Appendix S1).</p> <p>The main climatic requirements are met in a marginal (&gt;5% but &lt;20% - one fifth) part of the area.</p> <p>The confidence is medium because no formal species distribution modelling was produced.</p> |                    |

References:

Kottek, M., Grieser, J., Beck, C., Rudolf, B., & Rubel, F. (2006). World map of the Köppen-Geiger climate classification updated. *Meteorological Journal*, 15, 259–263.

**LIK5 Unaided secondary (dispersal) pathways**

Response: Unlikely

Confidence: Medium

Rationale: The species is slow moving and incapable of flying.

The confidence is medium because the extent of the establishment is unknown.

References:

Graham, S. A. (1957). The walking stick insect as a forest defoliator. *Michigan Sch. For Conservation of Circulation*; 3.

**LIK6 Human aided secondary (dispersal) pathways**

Response: Fairly probable

Confidence: Medium

Rationale: The confidence is medium as this species is available on the internet but not at pet shops.

However, this corresponds with the information obtained from the anonymous expert, whom was of the opinion that other breeders are still keeping the stick insects but they are afraid to sell them in public as they were told it is now prohibited to keep the Indian stick insects.

The species is used as a pet. Breeders were observed selling *Extatosoma tiarirum* which is a closely related species in the expositions in the South African pet trade.

This species has been reported to be found in the suburban gardens and natural fynbos in Cape Peninsula.

References:

Brock, P. D. (1998). New records of alien stick insects. *Phasmid Study Group*, 7, 39-40.

Bluithgen, N., Metzner, A., & Ruf, D. (2006). Food plant selection by stick insects (Phasmid) in a Bornean rain forest. *Journal of Tropical Ecology*, 22, 35.

### 3. Consequences

|   |             |
|---|-------------|
| <b>IMP1 Environmental impact (Figure 3)</b> |             |
| Response: DD                                | Confidence: |
| Rationale:                                  |             |
| References:                                 |             |
| <b>IMP1a: Competition</b>                   |             |
| Response: DD                                | Confidence: |
| Rationale:                                  |             |
| References:                                 |             |
| <b>IMP1b: Predation</b>                     |             |
| Response: DD                                | Confidence: |
| Rationale:                                  |             |
| References:                                 |             |
| <b>IMP1c: Hybridisation</b>                 |             |
| Response: DD                                | Confidence: |
| Rationale:                                  |             |
| References:                                 |             |
| <b>IMP1d: Transmission of disease</b>       |             |
| Response: DD                                | Confidence: |
| Rationale:                                  |             |
| References:                                 |             |
| <b>IMP1e: Parasitism</b>                    |             |
| Response: DD                                | Confidence: |
| Rationale:                                  |             |
| References:                                 |             |
| <b>IMP1f: Poisoning/toxicity</b>            |             |
| Response: DD                                | Confidence: |
| Rationale:                                  |             |

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| References:  |             |
| <b>IMP1g: Bio-fouling</b>  |             |
| Response: DD   | Confidence: |
| Rationale:   |             |
| References:  |             |
| <b>IMP1h: Grazing/herbivory/browsing</b>                           |             |
| Response: DD   | Confidence: |
| Rationale:   |             |
| References:  |             |
| <b>IMP1i: Chemical, physical or structural impact on ecosystem</b> |             |
| Response: DD   | Confidence: |
| Rationale:   |             |
| References:  |             |
| <b>IMP1k: Interaction with other alien species</b>                 |             |
| Response: DD   | Confidence: |
| Rationale:   |             |
| References:  |             |

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| <b>IMP2 Socio-economic impact (Figure 3)</b>   |                  |
| Response: MN   | Confidence: High |
| <p>Rationale: This species has been reported to be a minor garden pest in private gardens in San Diego and South Africa, and in some instances, pesticide was required. The impact seems to be confined to a relatively small area, and mainly to ornamental plants, arguably not major economic impacts. There is direct evidence to support this assessment, hence the confidence level is high.</p>   |                  |
| <p>References:</p> <p>Brock, P. D. (1998). New records of alien stick insects. <i>Phasmid Study Group</i>, 7, 39-40.</p> <p><a href="http://legacy.sandiegouniontribune.com/uniontrib/20041226/news_1m26sticks.html">http://legacy.sandiegouniontribune.com/uniontrib/20041226/news_1m26sticks.html</a></p> <p><a href="https://www.sandiegouniontribune.com/lifestyle/home-and-garden/sdut-walking-stick-insect-control-toxin-2014sep26-story.html">https://www.sandiegouniontribune.com/lifestyle/home-and-garden/sdut-walking-stick-insect-control-toxin-2014sep26-story.html</a></p> |                  |

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|--|------------------|
| <b>IMP2a: Agriculture</b>  |                  |
| Response: DD   | Confidence:      |
| Rationale:   |                  |
| References:  |                  |
| <b>IMP2b: Animal production</b>  |                  |
| Response: DD   | Confidence:      |
| Rationale:   |                  |
| References:  |                  |
| <b>IMP2c: Mariculture/aquaculture</b>  |                  |
| Response: DD   | Confidence:      |
| Rationale:   |                  |
| References:  |                  |
| <b>IMP2d: Forestry</b>   |                  |
| Response: DD   | Confidence:      |
| Rationale:   |                  |
| References:  |                  |
| <b>IMP2e: Infrastructure and administration</b>  |                  |
| Response: DD   | Confidence:      |
| Rationale:   |                  |
| References:  |                  |
| <b>IMP2f: Human health</b>   |                  |
| Response: DD   | Confidence:      |
| Rationale:   |                  |
| References:  |                  |
| <b>IMP2g: Human social life</b>  |                  |
| Response: MN   | Confidence: High |
| Rationale:<br>Stick insects were reported to be minor garden pest, by feeding on ornamental plants. There were several |                  |

reports of severe damage to plants, including of Ivy (*Hedera*). This got to a stage where pesticides were required to kill this species. In the Cape Town suburbs, it has also been reported to be a minor garden pest. According to the framework, the application of pesticides leads to a moderate score, however, in this case the impact score should be Minor because the impact seems to be confined to a relatively small area (mainly gardens), and mainly to ornamental plants and it is unlikely that pesticides will be used in a situation like this all the time.

The confidence level is high because there is direct relevant observational evidence to support the assessment.

References:

Arakelian, G. (2015). Indian stick insect (*Carausius morosus*). Pest Bull Los Angeles Cty Dep AgricComm; 2015.

Brock, P. D. (1998). New records of alien stick insects. *Phasmid Study Group*, 7, 39-40.

[http://legacy.sandiegouniontribune.com/uniontrib/20041226/news\\_1m26sticks.html](http://legacy.sandiegouniontribune.com/uniontrib/20041226/news_1m26sticks.html)

<https://www.sandiegouniontribune.com/lifestyle/home-and-garden/sdut-walking-stick-insect-control-toxin-2014sep26-story.html>

| IMP3 Closely related species' environmental impact   |                    |
|--|--------------------|
| Response: MO (Grazing/ herbivory/ browsing)  | Confidence: Medium |
| <p>Rationale: The confidence is medium because there is evidence to support these impacts from the literature but it is uncertain whether these impacts led to changes in community composition (which would make the assessment major).</p> <p>Long-term effects of the feeding behaviour of <i>Didymuria violescens</i> (same order as <i>Carausius morosus</i>) has resulted in the repeated defoliation (many phasmids have a 2-year cycle of high population density), of alpine ash, which caused high mortality and a decrease in trunk diameter (Mazneck, 1967). Mazanec (1968) also showed a light defoliation caused significant reduction in diameter growth for two growing seasons.</p> <p><i>Didymuria violescens</i> was shown to feed on various native species of <i>Eucalyptus</i> in Australia, preferring <i>E. robertsoni</i>, <i>Eucalyptus radiata</i>, <i>E. dives</i>, <i>E. dalrympleana</i>, <i>E. maculosa</i>, <i>E. viminalis</i> and <i>E. bicostata</i>, including the economically valuable alliances e.g. <i>E. delegatensis</i> (alpine ash) or <i>E. regnans</i> (mountain ash) which resulted in extensive defoliation. This species defoliated 650 square miles of Eucalyptus forest, an event deemed serious not only for direct negative effects of tree growth and survival but also the potential threat this might cause to the stability and efficiency of important water catchments (Readshaw, 1965).</p> <p>In Australia, Shepherd (1957) showed that severe defoliation of <i>Eucalyptus delegatensis</i> by <i>Didymuria violescens</i> has led to significant mortality and decreased rate of increase in trunk diameter of this timber tree native in the natural forest.</p> <p><i>Diapheromera femorata</i> has been reported to attack locust tree (<i>Robinia pseudoacacia</i>) used to “furnish the farm with posts and stakes” in New York State (Ferrisborough, 1874). The insects entirely stripped the trees of their leaves every second year. Over a period of 15 years, the increasing infestation resulted in nearly all of the locust trees being killed, and the insects spreading to nearby native trees (Ferrisborough, 1874).</p> <p>Paine (1968), reported an outbreak by <i>Graeffea crouanii</i> (same order as <i>Carausius morosus</i>) on the island of Taveuni (Fiji group) which “began to reach serious dimensions in 1958, and by April 1959 100 acres of</p> |                    |

coconuts were affected. By the end of 1961 the outbreak had extended over 500 acres in which the older fronds were at least 50 per cent defoliated and nearly 400 palms had been killed”.

In Guangdong Province, *Micadina yingdensis* (same order as *Carausius morosus*) damaged around 2000 hectares of *Castanopsis fissa* forest while around 400 hectares of trees were killed. The next year nearly 3000 hectares in the same region were infested, with the area of destroyed trees (50,000 m3 of timber valued at \$560,000) reaching 850 hectares (Chen 1992).

In china, *Baculum pingliense* (same order as *Carausius morosus*) reached damaging levels in Shaanxi Province. The insect individuals can eat remarkable quantities of both young and old foliage. (Ji et al. 2000 in Hennemann et al. 2008). This species alongside and *R. intersulcatus* have caused less damage, infest forests and gardens in Shaanxi Province, and the total area was 1400 hectares, including 360 hectares of crops and over 1000 hectares of forest (Chen, 1991).

References:

Chen, S., & He, Y. (1991). Three new species of *Baculum* attacking forest from China (Phasmida: Phasmatidae). *Science Silvae Sin*, 27, 229–33.

Chen S, He Y (1992) *Micadina yingdensis* new species: a new walking stick injurious forest pest from Guangdong Province. *Forest Restoration*, 5, 209.

Ferrisburgh, R. E. R. (1874). Letter. *New Yorker*.

Mazanec, Z. (1968). Influence of defoliation by the *phasmatid* *Didymuria violescens* on seasonal diameter growth and the pattern of growth rings in Alpine Ash. *Australian Forestry*, 32, 3–14.

Mazanec, Z. (1967). Mortality and diameter growth in Mountain Ash defoliated by phasmatids. *Australian Forestry*, 31, 221–23.

Readshaw, J. L. (1990). Phasmatid outbreaks revisiting. *Australian Journal of Zoology*, 38:343.

Shepherd, K. R. (1957). Defoliation of Mountain Ash, *E. delegatensis*, by Phasmids.

**IMP4 Closely related species’ socio-economic impact**

Response: NA

Confidence:

Rationale: A score for socio-economic impact was given under IMP2

References:

**IMP5 Potential impact**

Response: MN

Confidence: High

Rationale: The confidence level high because there is direct observational evidence to support the assessment.

*C. morosus* is polyphagous and is known to feed on different plants, however, there appears to be little information regarding the impacts of the species and which tree species *C. morosus* feeds on in South Africa. Even though closely related species have been reported to cause negative impacts on trees of economic importance, *C. morosus* is considered to be a minor pest and causes little environmental and socio-economic impacts throughout the world including South Africa.

References:

Chen, S., & He, Y. (1991). Three new species of Baculum attacking forest from China (Phasmida: Phasmatidae). *Science Silvae Sin*, 27, 229–33.

Chen, S., & He, Y. (1992). *Micadina yingdensis* new species: a new walking stick injurious forest pest from Guangdong Province. *Forest Restoration*, 5, 209.

Ferrisburgh, R. E. R. (1874). Letter. New Yorker.

Mazanec, Z. (1968). Influence of defoliation by the phasmatid *Didymuria violescens* on seasonal diameter growth and the pattern of growth rings in Alpine Ash. *Australian Forestry*, 32, 3–14.

Mazanec, Z. (1967). Mortality and diameter growth in Mountain Ash defoliated by phasmatids. *Australian Forestry*, 31, 221–23.

Readshaw, J. L. (1990). Phasmatid outbreaks revisiting. *Australian Journal of Zoology*, 38:343.

Shepherd, K. R. (1957). Defoliation of Mountain Ash, *E. delegatensis*, by Phasmids.

#### 4. Management

| MAN1 What is the feasibility to stop future immigration?  |                    |
|---|--------------------|
| Response: High  | Confidence: Medium |
| <p>This species lays many eggs and their eggs are small which makes them easy to smuggle into South Africa. A recent study on alien terrestrial invertebrates did not find them in the South African pet trade; emails and surveys were sent out searching for terrestrial invertebrate species that people are keeping.</p> <p>Below is the email from a breeder who wished to remain anonymous</p> <p>“With the recent legislation changes, I think very few people will be willing to help you as many of the invertebrate species are now illegal. Unfortunately I no longer keep any invertebrates as a family I was keeping (<i>Phasmatodea</i>) are no longer legal to keep/breed/distribute”</p> <p>As the pathway of this species is pet trade, it is likely that people will still be keeping and selling this species as other popular stick insects, e.g. Australian stick insect (<i>Extatosoma tiararum</i>), are available on the internet and at expositions in South Africa. <i>C morosus</i> was also found on the internet on South African websites but the advert was uploaded five years back.</p> <p>Rationale: Confidence is medium because information from the anonymous source is speculative and we could not find a physical specimen in pet stores during the duration of my MSc study.</p> |                    |
| <p>References:</p> <p>Anonymous</p> <p>Nelufule, T. (2018). An assessment of alien terrestrial invertebrate species in the pet trade in South Africa. Masters Thesis, University of Pretoria.</p> <p>Personal observation</p>   |                    |

| MAN2 Benefits of the Taxon  |                  |
|---|------------------|
| MAN2a Socio-economic benefits of the <i>Taxon</i>   |                  |
| Response: Low   | Confidence: High |
| <p>Rationale: The species has been introduced as pets and for laboratory use. These benefits can be replaced by</p> |                  |

|   |                  |
|---|------------------|
| native species e.g. <i>Bactrododema krugeri</i> .   |                  |
| The confidence level is high because the interpretation of information is straightforward and reliable.   |                  |
| References:<br>Picker, M. D., Griffiths, C. L., & Weaving, A. (2002). Insects of Southern Africa. Cape Town: Struik.  |                  |
| <b>MAN2b Environmental benefits of the <i>Taxon</i></b>   |                  |
| Response: Low   | Confidence: High |
| Rationale: Confidence is high because we have native stick insects that would provide any of the benefits provided by this species. The confidence level is high because the interpretation of information is straightforward and reliable. |                  |
| References:   |                  |

|   |                    |
|---|--------------------|
| <b>MAN3 Ease of management (Table 4)</b>  |                    |
| Response: Difficult (6)   | Confidence: Medium |
| Rationale: Detectability of this species is critically time dependent, they reproduce quickly and only takes 4-6 months to mature. Their eggs take up to six to eight months before hatching. Getting into the peoples gardens where they are found would be difficult. Therefore, this species is hard to manage.<br><br>Confidence is medium there is some direct observational evidence to support the assessment, but some information is inferred. |                    |
| References:<br>Picker, M., & Griffiths, C. (2011). Alien and invasive animals: A South African Perspective. Cape Town: Struik.<br><br><a href="http://legacy.sandiegouniontribune.com/uniontrib/20041226/news_1m26sticks.html">http://legacy.sandiegouniontribune.com/uniontrib/20041226/news_1m26sticks.html</a>   |                    |
| <b>MAN3a How accessible are populations?</b>  |                    |
| Response: 2   | Confidence: Medium |
| Rationale: The species is established in the gardens in the suburbs. It is difficult to access people's properties and, in some cases, individuals might be high up in vegetation or deep within it, making them hard to detect. Confidence level is medium because there is no study in South Africa that has documented their behaviour.  |                    |
| References:   |                    |

|   |                    |
|---|--------------------|
| Brock, P. D. (1998). New records of alien stick insects. <i>Phasmid Study Group</i> , 7, 39-40.   |                    |
| <b>MAN3b Is detectability critically time-dependent?</b>  |                    |
| Response: 2   | Confidence: Medium |
| <p>Rationale: Detectability is critically time-dependent because in winter these animals are harder to find than they are more camouflaged in winter.</p> <p>Confidence level is medium because other studies have shown that this species is camouflaged and hard to find during the day.</p>  |                    |
| <p>References: Brock, P. D. (1998). New records of alien stick insects. <i>Phasmid Study Group</i>, 7, 39-40.</p> <p>Picker, M., &amp; Griffiths, C. (2011). Alien and invasive animals: A South African Perspective. Cape Town: Struik.</p>  |                    |
| <b>MAN3c Time to reproduction</b>   |                    |
| Response: 2   | Confidence: High   |
| <p>Rationale: Eggs hatch in 4–6 months and nymphs take 4–6 months to mature. Confidence level is high because there is evidence to support this in the literature.</p>  |                    |
| <p>References:</p> <p>Picker, M., &amp; Griffiths, C. (2011). Alien and invasive animals: A South African Perspective. Cape Town: Struik.</p>   |                    |
| <b>MAN3d Propagule persistence</b>  |                    |
| Response: 0   | Confidence: Medium |
| <p>Rationale: Outdoors, most eggs would be laid in late summer, or early autumn, before the onset of cold weather. This suggests an incubation period of six to eight months before eggs hatch to start the annual cycle again. However, no study has been conducted to find out if this is also happening for the species established in Cape Town suburbs. Hence, the confidence level is medium.</p> |                    |
| <p>References:</p> <p><a href="http://PhasmidstudyGroup.org/">http://PhasmidstudyGroup.org/</a> Accessed 18 July 2018.</p>  |                    |

|  |                 |
|--|-----------------|
| <b>MAN4 Has the feasibility of eradication been evaluated?</b> |                 |
| Response: No   | Confidence: Low |

Rationale: The confidence level is low because I have not come across any literature on the eradication of this species.

References:

## 5. Calculations

### Likelihood = Fairly probable

| Parameter | Likelihood      | Stages                       | Final assessment               |
|-----------|-----------------|------------------------------|--------------------------------|
| LIK1      | 1               | P(entry) = 1                 | P (invasion) = fairly probable |
| LIK2      | 1               |                              |                                |
| LIK3      | Probable        | P(establishment) = Probable  |                                |
| LIK4      | Fairly probable |                              |                                |
| LIK5      | Unlikely        | P (spread) = Fairly probable |                                |
| LIK6      | Fairly probable |                              |                                |

### Consequence = MO

| Parameter | Mechanism/sector                      | Response |
|-----------|---------------------------------------|----------|
| IMP1a     | Competition                           | DD       |
| IMP1b     | Predation                             | DD       |
| IMP1c     | Hybridisation                         | DD       |
| IMP1d     | Disease transmission                  | DD       |
| IMP1e     | Parasitism                            | DD       |
| IMP1f     | Poisoning/toxicity                    | DD       |
| IMP1g     | Bio-fouling                           | DD       |
| IMP1h     | Grazing/herbivory/browsing            | DD       |
| IMP1i     | Chemical, physical, structural impact | DD       |
| IMP1k     | Interaction with other aliens         | DD       |
| IMP2a     | Agriculture                           | MC       |
| IMP2b     | Animal production                     | DD       |
| IMP2c     | Mariculture/aquaculture               | DD       |
| IMP2d     | Forestry                              | DD       |
| IMP2e     | Infrastructure                        | DD       |

|       |   |    |
|-------|---|----|
| IMP2f | Human health  | DD |
| IMP2g | Human social life   | MN |
| IMP3  | Environmental impact of closely related taxa<br>(only score if IMP1a-k are all DD, otherwise NA)  | MO |
| IMP4  | Socio-economic impact of closely related taxa<br>(only score if IMP2a-g are all DD, otherwise NA) | NA |
| IMP5  | Potential impact based on traits, experiments, or models  | MN |

**Risk = High**

|            |                    | Consequences |        |        |        |        |
|------------|--------------------|--------------|--------|--------|--------|--------|
|            |                    | MC           | MN     | MO     | MR     | MV     |
| Likelihood | Extremely unlikely | low          | low    | low    | medium | medium |
|            | Very unlikely      | low          | low    | low    | medium | high   |
|            | Unlikely           | low          | low    | medium | high   | high   |
|            | Fairly probable    | medium       | medium | high   | high   | high   |
|            | Probable           | medium       | high   | high   | high   | high   |

**Ease of management = Difficult**

| Parameter   | Question                                    | Response |
|-------------|---|----------|
| MAN3a       | How accessible are populations?             | 2        |
| MAN3b       | Is detectability critically time-dependent? | 2        |
| MAN3c       | Time to reproduction                        | 2        |
| MAN3d       | Propagule persistence                       | 0        |
| <b>MAN3</b> | <b>SUM</b>                                  | <b>6</b> |

**Appendix BAC7:** Provide here a map of the native range, if possible. If the map is available in a file, please insert a low res copy (<1MB) and provide the file name and (if possible) a link to a higher resolution copy below (Picker and Griffiths 2011).



**Appendix BAC8 (a):** Provide here a map of the global alien range if possible. If the map is available in a file, please insert a low res copy (<1MB) and provide the file name and (if possible) a link to a higher resolution copy below (GBIF 2018).



Map of global alien range of *Carausis morosus*. The zooming in does not exclude any populations (GBIF 2018)  
[Accessed 30 august 2018]

**Appendix BAC8(b):** Provide here a map of the alien range in the *Area* if possible. If the map is available in a file, please insert a low res copy (<1MB) and provide the file name and (if possible) a link to a higher resolution copy below (Brock 1998).



Appendix 1.

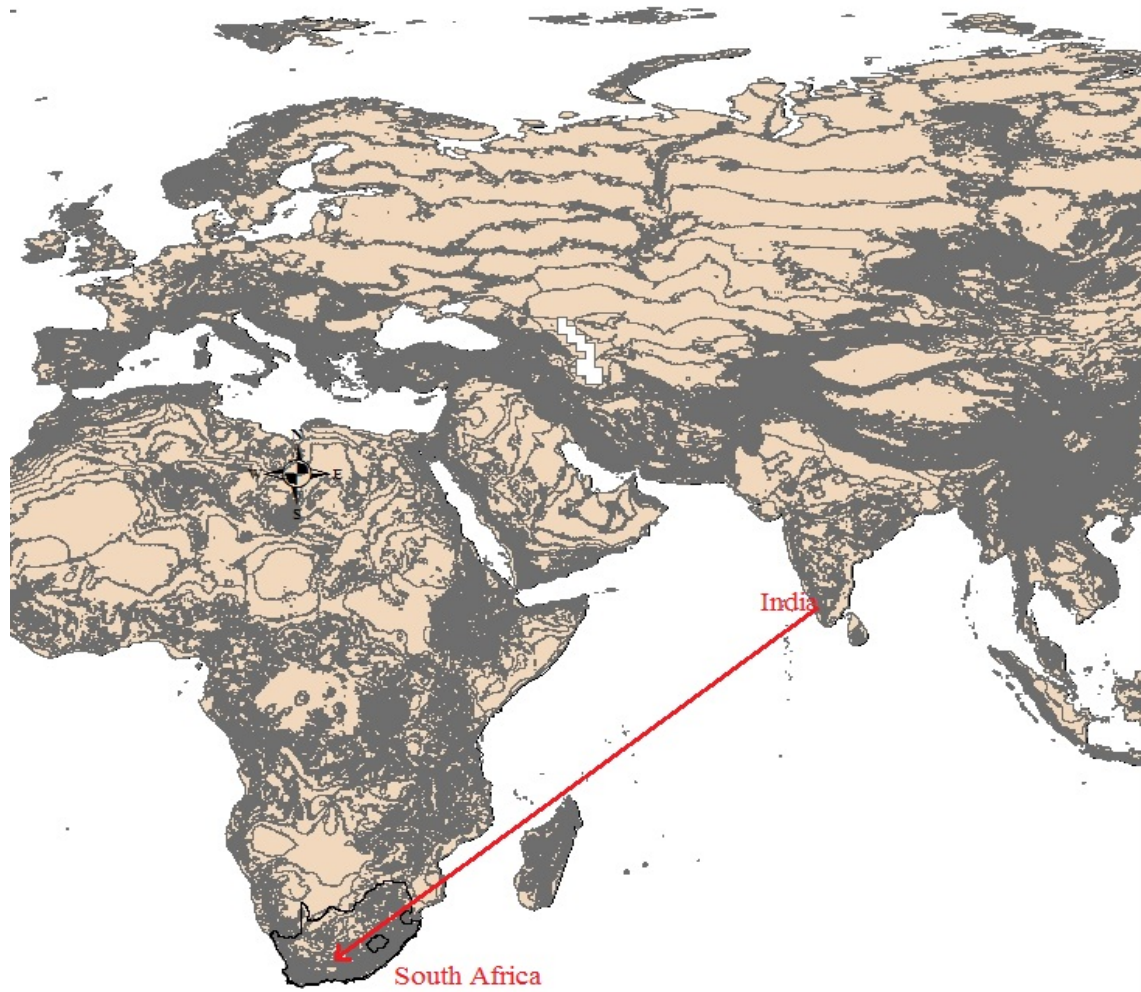


Figure S1. A map showing climatic climate zones between India and of South Africa.