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AUSTRALIAN GLOW-WORMS: MANAGING AN IMPORTANT BIOLOGICAL RESOURCE

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ABSTRACT

Australian glow-worms are a unique resource for tourism in Australia and New Zealand, yet in Australia little information is available on the species present and their relative distributions. An understanding of Australia's biologically distinct species will indicate the need for specific populations to have strategic management plans put in place for their future protection. To get to this stage, three basic questions must be answered:

- Where are glow-worms found in Australia?
- What species are they?
- What likely threats can potentially impact on these colonies?

This information is imperative for underpinning management decisions for the future protection of glow-worm populations in Australia. During this study, knowledge of glow-worm distribution in Australia has been largely increased to now include far north Queensland and many new sites through New South Wales and Victoria. Glow-worm populations were found in fragmented rainforest habitat and isolated wet cave systems. Molecular, reproductive and morphological findings indicate strong evidence for allopatric speciation (speciation due to geographic separation) between colonies and suggest up to six new species are present within Australia. Several colonies are noted for their small geographic range and therefore an increased need for protection.

INTRODUCTION

The "glow-worm" I refer to is the larval stage of a primitive fly (Diptera: Keroplatidae: *Arachnocampa* spp.). Previous taxonomic work on this taxon has revealed four species (Skuse 1890, Ferguson 1925, Harrison 1966). The world famous *A. luminosa* Skuse of New Zealand, southeast Queensland's *A. flava* Harrison, *A. richardsae* Harrison from New South Wales and the endemic Tasmanian species, *A. tasmaniensis* Ferguson.

Being fly larvae, a more literal description of this organism would be "glow-maggot", however there is little chance this name will catch on in the tourism market. Two Australian species have been studied under laboratory conditions: *A. flava* (Baker 2002, Baker and Merritt 2003) and *A. richardsae* (Takaie 1989, 1997). There are many noted similarities between these species and the widely studied New Zealand species, *A. luminosa* (Richards 1960, Gatenby 1960, Stringer 1967, Pugsley 1980, Meyer-Rochow 1990, Broadley 1998). However differences are also evident. Larvae have the longest life span of all of the life stages. Egg development in *A. flava* takes 10 days with the larvae then living for up to one year depending on prey availability and environmental conditions. *A. flava* larvae then pupate for 7-9 days and emerge as adult flies. The adults have very short life spans with females living for 2 days and males no longer than 6 days. Adults are considered poor flyers, thereby restricting their ability to colonise new areas (Richards 1960, Baker and Merritt 2003).

AUSTRALIAN GLOW-WORM TOURISM

Australian glow-worm tourism is a multi-million dollar industry, thereby making glow-worms a commercially valuable organism. Despite this fact, no biological or ecological research followed the increase in utilisation of these species until 1999 when a study focused on *A. flava* in Springbrook National Park, southeast Queensland (Baker 2002). In the study a number of factors were examined to isolate tourism impacts on this heavily visited glow-worm population. The life cycle of the species was recorded to gain an understanding of each life stage of the fly and compare it to the extensively studied *A. luminosa*. Potential prey of *A. flava* at this site was found to be predominantly small flies and collembola (Springtails). Experiments showed larvae were negatively affected by torchlight. Larvae moved away from the torchlight while switching off their own light source. Larvae took up to ten minutes to turn their light back on, thereby decreasing the density of the display for following tourists. Correlations between climatic data and the number of glow-worms glowing at both the heavily visited tourism site and a non-visited site revealed similar overall fluctuations, indicating weather was the major factor involved in population crashes at particular times of the year. Population crashes occurred at both sites during conditions of low rainfall, temperature and relative humidity (Baker 2002).

Management issues highlighted in this study pointed out that although tourism impacts at this site had less of an effect on the colony than natural climatic factors, a number of measures needed to be taken to ensure tourism impacts remained low. Issues addressing visitor awareness were addressed. As tourists visit this site during the day and night, interpretive information boards, outlining glow-worm biological information, were installed to increase general knowledge of organisms within the region. Dangerous activities and potential human impacts were outlined on the information boards. Tour operator awareness was increased through personal communication and an increase in available information on biological factors of importance to the glow-worms (Baker 2002).

CURRENT RESEARCH

The study based at Natural Bridge indicated the need for more research on glow-worms Australia-wide in order to firstly document populations and then provide specific protection for each rainforest or cave site. Unlike New Zealand, glow-worm populations in Australia are completely isolated from one another in geographically and vegetatively fragmented rainforest or cave habitats referred to as islands of refugia (Adam 1992). Three Australian endemic species have been described, but it was evident that more geographically isolated populations existed, thereby representing potential new species. Each of these populations is subject to different forms of survival pressure including climatic change, further fragmentation of habitat and high tourist visitation levels. This project aims to:

- Document glow-worm distribution in Australia
- Identify and describe Australian species of glow-worm
- Analyse glow-worm colonies at a morphological, reproductive and genetic level to determine the evolutionary history of the Australian glow-worm fauna
- Outline case studies of specific sites from which management plans can be applied for protection of the species.

DISTRIBUTION OF AUSTRALIAN GLOW-WORMS

Literature searches were conducted to establish published glow-worm locations within Australia. Sixteen identified sites (Ferguson 1925, Perkins 1935, McKeown 1935, Harrison 1966, Geode 1967, Crosby 1978, Finlayson 1982, Anon. 1994) were visited during March, 2000. Potential glow-worm colony sites not recorded in the literature were determined using a collation of local vegetation maps, rainfall data, local knowledge (e.g. telephone surveys of active cavers and National Parks officers) and collated data from known field sites. Habitat for glow-worms was determined through their requirements of constant high humidity and an association with water. Field surveys to these sites were conducted during March and June-July, 2000 and geographical distribution data was collated and data based. The known *Arachnocampa* distribution range has been largely increased to now include north Queensland locations and sites through New South Wales and Victoria (Fig 1). Glow-worm populations can be separated into distinct geographic regional groups (Fig 1). Gene flow between regional groups is unlikely due to the poor flying ability of adults and the large geographic distance between suitable glow-worm habitat sites.

SPECIES IDENTIFICATION

Once glow-worm distribution is established, species determination is necessary to gain an understanding of glow-worm speciation within Australia in order to protect potentially vulnerable populations. A small number of larvae were collected from each visited site for species analysis. Species are being identified using four criteria; morphological differences, genetic divergence, reproductive isolation and geographical barriers (Fig 1). Classic taxonomic techniques were applied to determine morphologically distinct species and describe these species. Genetic analysis is being used to determine species groupings and investigate the evolutionary history of the taxa. Mating trials were conducted to determine physical barriers operating between species and populations.

Morphological identification presently indicates six new species. Genetic analysis indicates further division of regional glow-worm groups due to long-term lack of gene flow between the populations. Mating trials between and within regional groups of glow-worms revealed high specificity in mate recognition within and between regions. Adult *Arachnocampa* from within the same colony group would mate immediately when introduced (n=8). One out of 22 inter-regional crosses resulted in a successful mating. However oviposited eggs did not hatch and subsequent crosses with newly emerged virgin adults from these populations resulted in no mating. Crosses of adults within the same designated region were expected to be successful. However three intra-regional crosses were unsuccessful, indicating non-mate recognition within designated regional groups (i.e. speciation).

When combined with geographical distribution data, these findings show the need for thorough species identification in providing a basis for managerial decisions surrounding protection of endemic species restricted by geographical barriers.

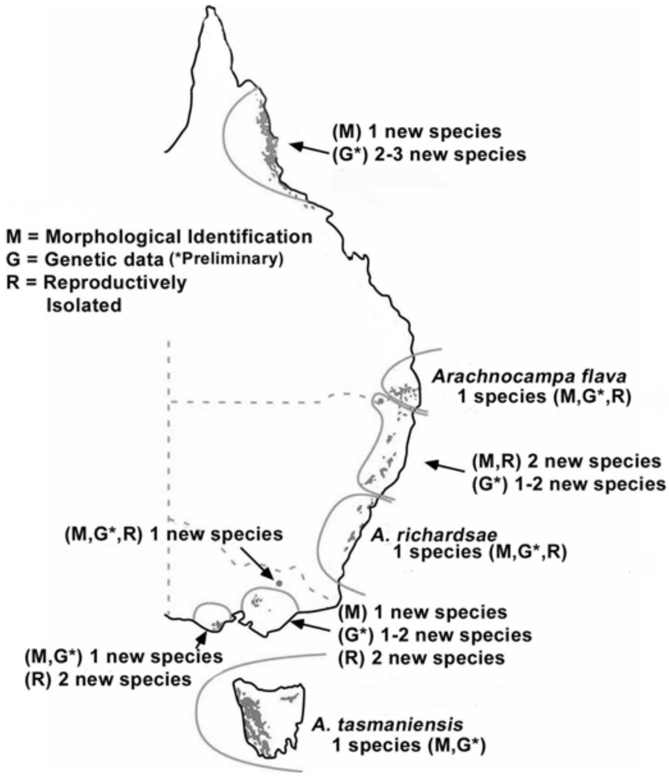

Figure One

CASE STUDIES OF VULNERABLE POPULATIONS

Three scenarios of glow-worm vulnerability were exemplified through specific case studies indicating the threatening processes affecting their survival.

1) Tourism

Glow-worm tourism in Australia has not been assessed despite its increasing popularity. This study aimed to document areas of glow-worm utilisation and survey tour operators to determine the usage of glow-worms as a resource for tourism in Australia. Factors involving annual tourist numbers, tour types, land ownership and usage of biological information incorporated into each tour were determined. This information will be used in collaboration with distribution data and species identifications to provide guidelines for protection of both the glow-worms and the associated tourism ventures.

Although each glow-worm site has linking factors involved in suitability of the site for glow-worms, every site was noticeably unique whether it be due to variations in colony size, visitor numbers, vegetation, or habitat type (e.g. rainforest banks, caves or overhangs). Many sites encounter high visitor traffic but awareness of glow-worms, especially of vulnerable populations, is generally not available unless the tourists are part of a commercial glow-worm tour.

Although tourists observe glow-worm bioluminescence in the dark (i.e. only at night for rainforest populations), impacts can occur on the living organism at any time. Further studies should incorporate visitor impacts of those not involved in glow-worm tours with the aim of providing informative interpretation for glow-worm protection.

2) Parasitic wasp

North Queensland populations were heavily infected by a new species of parasitoid wasp (31% of field collected north Queensland glow-worm larvae displayed wasp emergence, 37% glow-worm larvae died in the laboratory and 32% glow-worm larvae were reared through to adulthood successfully). The adult wasp lays an egg into a glow-worm larva, where the wasp larva then develops inside its live victim until the wasp is ready to pupate whereupon it kills its glow-worm host before emerging as an adult wasp. This wasp may be a controlling factor in the observed low larval numbers within these colonies. The parasitoid is currently only found in north Queensland glow-worm populations and could prove catastrophic to southern glow-worm tourism regions. The wasp is currently being identified and its biology described.

3) Restricted habitat

The Mt Buffalo glow-worm was recommended for listing as a threatened species because of its extraordinarily restricted distribution to one sub-alpine cave, Mt Buffalo, Victoria. This followed its identification as a new species and the discovery that morphologically this species resembles the New Zealand and Tasmanian species rather than geographically closer populations found in Victoria (Yarra Valley Region, Otway National Park and Walhalla). The conservation status of the Mt Buffalo glow-worm is gauged as extremely rare based on its restricted distribution of one cave. The occurrence as a single isolated population is one factor that threatens the species. The other factor is the very specific habitat requirements of glow-worms. They have adapted to very predictable high humidity climates and are particularly vulnerable to climate and environmental change. Specific requirements include a very high relative humidity, a constant food supply, water and a protected overhang to build a snare. Human impacts will contribute to likely threats as the cave is used extensively during the summer months for recreational caving. A number of tour operators have licences to access the cave and the cave is open for visitors to the park to enter at any time, thereby further increasing threats to glow-worms from perhaps unknowing tourists.

Protection for this species relies heavily on its taxonomic description linking it closely to New Zealand and Tasmanian species rather than the geographically closer Australian mainland species.

CONCLUSION

When determining the vulnerability status of species, a number of factors must be taken into consideration. Most importantly we must understand biologically what we are dealing with to establish useful management plans. For Australian glow-worms specifically, correct species identifications and distribution data of each species is imperative as their poor dispersal skills restrict them to areas they currently inhabit. A number of factors impact on their success and each site must be individually assessed to protect vulnerable populations.

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