Visual census, photographic records and the trial of a video network provide first evidence of the elusive *Sicyopterus cynocephalus* in Australia

by

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Abstract. – Opportunistic encounters with an elusive large-bodied sicydiine goby in a single plunge pool led us to photograph and deploy three video cameras to detect individuals in that pool. Subsequently, a catchment-wide search indicated that the species, eventually identified as Sic*yopterus cynocephalus*, was confined to the single pool where it was originally detected. A network of ten video cameras was then deployed to estimate the number of individuals of that species and of a congener, *S. lagocephalus,* by non-destructive means. This study provides the first record of *S. cynocephalus* in Australia, and showcases the synergy of active snorkel searches and a remote camera network in counting individuals of two sympatric species of *Sicyopterus*.

Résumé. – Recensement visuel, documents photographiques et réseau vidéo fournissent la première preuve de la présence de *Sicyopterus cynocephalus* en Australie.

Des rencontres fortuites avec un gobie Sicydiinae de grande taille et furtif, dans une piscine naturelle, nous ont conduit à photographier et à mettre en place un réseau de trois caméras vidéo pour détecter les individus présents dans cette piscine. Par la suite, une recherche à l'échelle du bassin versant a montré que la présence de cette espèce, identifiée comme étant *Sicyopterus cynocephalus,* se limitait à la piscine où elle avait été initialement détectée. Un réseau de dix caméras vidéo a ensuite été déployé pour estimer le nombre d'individus de cette espèce ainsi que celui d'un congénère, *S. lagocephalus*. Cette étude fournit le premier signalement de *S. cynocephalus* en Australie, et montre l'intérêt des observations menées en apnée couplées à l'utilisation d'un réseau de caméras à distance pour procéder au comptage des individus de ces deux espèces sympatriques de *Sicyopterus*.

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Major challenges in studying species that are both rare and elusive include encountering individuals in the first place, providing evidence of their presence (McKelvey *et al.,* 2008) and then being able to re-observe individuals in order to maximise information gain. In clear-water rivers and streams, visual techniques such as snorkelling and underwater video provide an opportunity to survey fishes, including rare and elusive species and to develop an understanding of their behaviour and habitat use (Zuanon *et al.,* 2006; Ebner *et al.,* 2014, 2015; Schmid *et al*., 2016).

Certain sicydiine goby species are shy and prone to hiding whilst an observer (*e.g*. snorkeller) is in the stream. For instance, species of *Sicyopterus* are often alarmed and flee into turbulent water and/or streambed interstices when first encountered by an observer, although this depends to some extent on how the snorkeller approaches the fish (Ebner, pers. obs.). It is well established from visual surveys in marine systems that some fishes are diver shy or negative, whereas, at the other end of the spectrum some species are diver positive; creating bias in estimates of population density and species richness. For instance, Dickens *et al*. (2011) found that most reef fishes avoid divers and that some groups (*e.g*. parrotfishes) are more prone to avoiding divers than others (*e.g*. wrasses, butterflyfishes). They also contended this was mainly as a result of seeing divers rather than for instance hearing them. Therefore, it is not surprising that certain fishes are more effectively detected by remote camera rather than by direct diver observation (*e.g*. Fox and Bellwood, 2008).

Remote video applications facilitate detection of diver-negative species and can provide evidence of observation (Fox and Bellwood, 2008; McKelvey *et al.,* 2008), whereas, snorkel surveys are effective for detecting and counting conspicuous diurnal stream fishes, including a subset of locally rare sicydiine gobies (*e.g*. *Stiphodon*) in short-steep-coastal streams (Boseto *et al.,* 2008; Ebner and Thuesen, 2010; Ebner *et al.,* 2015). Back-pack electrofishing is effective for sampling fishes in shallow water sections (*e.g*. < 1 m)

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of flowing streams (Pusey *et al.,* 1998; Allard *et al.,* 2014; Macnaughton *et al.,* 2015), but is nonviable beyond depths of about 1.5 m, and can be problematic in shallower water at high flow rates (*e.g.* 1 ms^{-1}). Furthermore, in reaches inaccessible by road or boat (*e.g.* steep-rainforest-catchments, confined gorges) boat-based electrofishing is clearly not an option (Ebner *et al.,* 2015).

A number of sicydiine gobies have been detected in short-steep-coastal-streams of the Australian Wet Tropics in the past decade (*e.g.* Thuesen *et al.*, 2011) and four of these are now threatened species under state or national legislation in Australia. Given the rarity of these species, researchers have resisted collecting voucher specimens in situations where very few individuals are apparent, choosing to observe these small populations in order to learn more about the fishes. Under such circumstances, it is important to meet minimum evidentiary standards validating the records of species. McKelvey *et al.* (2008) discuss different types of evidence and the circumstances under which there is confidence in the records of rare species. In that paper the authors contend that visual observations of rare species vary in their value. For instance, a visual observation of a species is less reliable than a photograph or video record of the observation, which in turn is less reliable than a photograph or video, which clearly shows a diagnostic characteristic of the species. There is also lively debate regarding the suitability of photographic and video based evidence of rare species and indeed the formal description of new species to science (*e.g.* Howell *et al.*, 2014; Ceriaco *et al.*, 2016).

In the current study, the aim was to use direct and indirect visual observation techniques to document the existence of an elusive fish species and estimate minimum population size. A secondary focus was comparing counts of this species, a common congeneric species and the general fish assemblage using a network of cameras compared with active searching with mask and snorkel. Specifically, we hypothesised that a video network would reveal high overall counts of *Sicyopterus* relative to snorkelling since these species are diver-negative.

METHODS

Study site

This study was conducted at an unnamed coastal stream south of Cairns, Australia, with an average stream gradient of 18.4%, a maximum catchment elevation of 577 m above mean sea level (Graham Range) draining an approximate catchment area of 1.7 km^2. The area receives high annual rainfall (~4000 mm $year^{-1}$) and is dominated by rainforest-clad ranges bordering the Russell-Mulgrave River system. The stream is perennial, and water is extracted from the sys-

Figure 1. – Study site. **A**: Waterfall and bedrock section of stream immediately upstream of the plunge pool; **B**: Upper section of the plunge pool; **C**: Lower section of the plunge pool. All photographs taken from the right stream bank, and note that there is an underwater cave underneath the slab of rock upon which the photographer was standing.

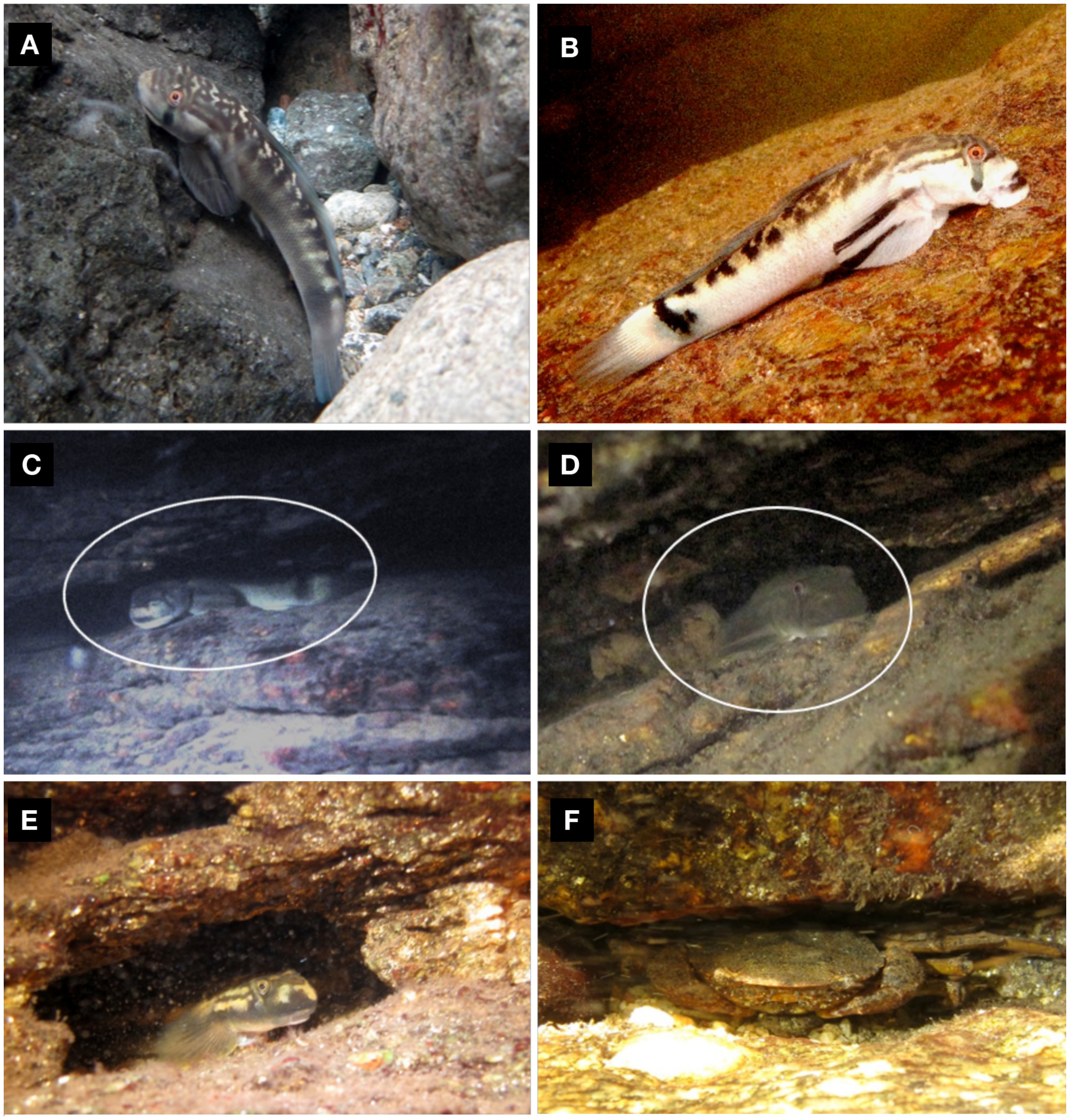

Figure 2. – Benthic habitat use and appearance of select species. **A**: Brown morph of male *Sicyopterus cynocephalus* as seen in the plunge pool initially on the first visit (however, this image was obtained in the Solomon Islands), with all other images captured from the study site; **B**: White morph of a large (~180 mm TL) male *S. cynocephalus* grazing; **C**: Another large male (~200 mm TL) at the front of the crevice that it consistently occupied during active searches by researchers; **D**: A female *S. cynocephalus* in a crevice; **E**: *S. lagocephalus* in a small cave/crevice; **F**: A freshwater crab occupying a crevice. All images photographed with a Canon G10 still camera. Date of photographs. A: September 2015; B-E: 30 June, 2014; F: 18 September, 2014.

tem to supply a small settlement of approximately 60 dwellings (Ebner pers. obs.).

First field visit

On 29-30 June 2014, an opportunistic snorkelling survey (including use of an underwater torch) of the lower course of the stream by the first author revealed the presence of a large individual of an unknown species of *Sicyopterus* in a pool at the base of a waterfall (Fig. 1). The pool was at an elevation of approximately 4 m above sea level (ASL) and approximately 65 m from the ocean. Total length of the individual was estimated as per described in Ebner and Thuesen (2010). The researcher returned the following day and photographed (Canon G10) an individual of this species, taking care to minimise disturbance from the pools edge. The proximity of the individual and its relaxed behaviour provided ideal conditions for estimating its total length (relative to the encounter with an individual the previous day) with accuracy likely to be in the order of ± 10 mm. Three GoPro cameras (Hero2; San Mateo, California, USA) were then mounted on single dive weights and deployed in nonrandom micro-locations where the species had either been seen or was anticipated to visit within the pool. Filming spanned greater than 1 hour. Upon completion of the filming the researcher thoroughly surveyed the plunge pool for the unidentified *Sicyopterus* species, to get a count of males and females, and an estimate of their total length. Weather conditions were overcast and there was intermittent rain during these two days.

Second field visit

On 17-18 September 2014 (mid-way through the dry season), a return visit was made to the study site where the unidentified *Sicyopterus* sp. had first been observed three months prior. An effort was made to describe the pool [maximum dimensions: 11.40 m × 8.0 m × 1.6 m deep], which was dominated by structurally complex habitat including tree roots, undercut banks and crevices in the coarse-grained granitic rock and a substratum composed primarily of bedrock and leaf litter. Observations from an earlier visit revealed that these crevices (of unknown dimension) were used by the unidentified *Sicyopterus* sp. as refuges, effectively hiding them from the observer's view (Fig. 2C-E). At this site, the unidentified *Sicyopterus* sp. is sympatric with *S. lagocephalus* (Pallas, 1770), a congener from which it is difficult to distinguish, especially when individuals are in non-breeding colours. While it was easy to distinguish these two species from one another on the first field visit, it was more problematic on the second field visit (in part due to changes in the colouration of *S. lagocephalus*). Therefore we had to group the two species as a single entity for video analysis and count data resulting from snorkel searches on the latter trip. Movement of individuals into or out of the pool during the survey period was restricted by a small vertical drop blocked by a net (2 mm stretched mesh) at the downstream exit and a large (> 10 m) vertical rock face and waterfall on the upstream end of the pool.

To reduce disturbance, we first prepared ten unbaited GoPro cameras for deployment on-shore. The cameras were placed in a circle facing each other, turned on and time-synced using hand signals. All cameras were set to record at 960p, 30 feet per second (FPS) with a wide angle (170°) field of view. Based on field of view settings, ten cameras were deployed underwater in a non-overlapping formation focussing on areas where *Sicyopterus* individuals had been observed most frequently and to cover as much of the pool as possible, especially the pool edges. Non-overlapping fields of view were used to preclude the possibility of double counting individuals. The last camera was deployed at 8:07 AM and all cameras were retrieved at 9:17 AM.

Processing video

The footage obtained from three remote video cameras on the first field visit served only to collect images for identifying fishes and particularly the unidentified *Sicyopterus* sp. and acted as a learning experience in preparation for the more extensive deployment of cameras on the second field visit. The footage collected from filming with ten cameras simultaneously, was viewed in relation to one camera at a time. One hour of footage from each camera, viewed using VLC Media Player (version 2.0.4; VideoLAN, Paris, France), was processed in accordance with starting at two minutes after the final camera was deployed (calculated based on synced-time). Time of first arrival and MaxN (maximum number of individuals of a species in field of view at any one time) was recorded in relation to each species observed. Time of first arrival enables construction of species accumulation curves in relation to effort, and it was also anticipated that keeping track of which camera a species is first revealed on might provide some insight into where species were hiding in the pool. For *Sicyopterus* spp., the number of individuals in the field of view at any time was recorded on a second-by-second scale across all ten cameras. Data from each camera was then combined to give a network MaxN termed NetworkN.

Snorkel surveys

Two experienced snorkellers (BCE, JAD) entered the pool at the downstream end on completion of video recording, each surveying the entire pool simultaneously with the aid of an underwater torch. Data including MaxN, total minimum number of individuals and an estimated size range for all fish species and crustaceans (although Crustacea were often not distinguished to species level) were taken by the observers following snorkel survey protocols as described in Ebner and Thuesen (2010) and based on familiarity with relevant field guides (*e.g.* Allen *et al.*, 2002; Marquet *et al.*, 2003; Keith *et al.*, 2010).

RESULTS

First field visit

On 29 June 2014, the researcher observed a single large individual (about 180 mm TL) of *Sicyopterus* sp., which had a distinctly red iris, a predominantly brown body colour with darkened saddles, brown and yellow mottling on the nape and two darkened pectoral fin stripes. The fish quickly retreated amongst boulders, and consequently it was not photographed. The identity of this species was not known to the researcher at the time. However, an image of a similar colour morph from the Solomon Islands is provided in figure 2A (which was obtained at a later point in time). Photographs of the male as a predominantly white colour in the plunge pool were taken on 30 June 2014 (Fig. 2B). Subsequent review by taxonomic co-workers (third and fourth authors) confirmed the species identity as *Sicyopterus cynocephalus* (Valenciennes, 1837). Specifically, the large male with an elongated body, a mottled nape, dorsal bandlets, prominent black stripes on the pectoral fins and a red iris, is unlike other described species of *Sicyopterus* (Keith *et al.,* 2015). The count of *S. cynocephalus* in the plunge pool (based on a single researcher snorkelling on 30 May 2016) was two large white-morph males (200 mm, 180 mm) and one brown-morph male (TL = 140 mm) and seven individuals (70-85 mm TL) that were plain brown in colour without mottled marking on the nape or prominent bandlets on the dorsal surface and flanks (*i.e.* assumed females and possibly some subordinate males based on our collective experience with this species elsewhere; note these individuals were in small caves and crevices in the plunge pool). All individuals of *S. cynocephalus* had a red-coloured iris.

S. lagocephalus were also present in the plunge pool, however, exact counts of that species are only available for a 50 m section of the stream (at least 10 individuals, n = 5 males: 75-90 mm TL; n = 5 females: 70-110 mm TL) and are therefore not exclusive to the plunge pool. *S. lagocephalus* had a white or a copper-yellow iris, and males were strongly or partially coloured (see descriptions of sex-specific body colour in this species in the Australian Wet Tropics in Ebner *et al.,* 2011, and more widely in Keith *et al.,* 2015).

Second field visit

Snorkel surveys conducted by two observers yielded a higher estimate of minimum population size for *Sicyopterus* spp. (ten individuals) compared to video cameras (five individuals) in the surveyed pool (Tab. I). However, cameras recorded a higher MaxN value for *Sicyopterus* spp. (3 individuals) compared to snorkelling (1 individual). In total, nine species were recorded using a combination of two visual techniques (Tab. I), however, species could not be definitively attributed in some cases. For instance, *Eleotris fusca* was observed by snorkellers and was almost definitely observed on video during the current study, though this species is outwardly very similar to *E. melanosoma* Bleeker, 1852, and *E. acanthopoma* (Bleeker, 1853) which are also present in the Wet Tropics (*e.g.* Allen *et al.,* 2002) (Note: in terms of morphologically similar fishes we have only collected *E. fusca* and *Bunaka gyrinoides* from this and nearby small coastal streams of the Graham Range, to date). Two individuals of a large, dark eleotrid were observed in caves briefly with the aid of a torch, but were not *E. fusca*, these have simply been recorded as Eleotridae sp. (Tab. I). Snorkel surveys observed several species not detected by cameras, whereas, the reverse was not the case (Tab. I).

Video

Initial processing of the video to extract time of arrival and MaxN data for each species observed took an average of 33.9 min (± 3.6 SE) across the ten cameras to process, while secondary processing of the footage to extract continuous real-time MaxN data for *Sicyopterus* spp. took approximately 15 hours in total. Mean arrival time for *Sicyopterus* spp. on the cameras (8 cameras with positive detection) was 18.0 minutes (± 4.3 SE) (min. = 5.7 min, max. = 35.1 min). MaxN recorded on each of 10 cameras ranged from 0-3 individuals (Fig. 3). The greatest NetworkN value for the video footage was five individuals and was calculated by counting the cumulative number of *Sicyopterus* spp. in the field of view across the 10 cameras at any one moment (Fig. 4). The overall pattern on NetworkN suggests that it took *Sicyopterus* about 30 minutes to adjust to the presence of the cameras and probably the manual deployment of the cameras (Fig. 4).

Snorkelling

Snorkel surveys primarily detected *Sicyopterus* spp. sheltering in small crevices from which they did not appear to leave during the search period, providing a high degree of confidence that individuals were not counted twice. A

Table I. – Detection of species by active snorkel surveys and video cameras. MaxN provides the highest maximum number of individuals of a species encountered on a camera or from a single view whilst snorkelling. Total min is the minimum number of individuals of a species estimated by snorkelling or simultaneously in view of ten cameras (*i.e.* NetworkN).

Species	Primary active period	Cryptic	MaxN		Total min	
			Snorkel	Camera	Snorkel	Camera
Anguilla reinhardtii Steindachner, 1867	Nocturnal	Yes	1	0	1	Not calculated
Eleotris fusca (Bloch & Schneider, 1801)	Nocturnal	Yes	1	1	1	Not calculated
Eleotridae unidentified sp.	Nocturnal	Yes	1	0	2	Not calculated
Unid. freshwater crab	Unknown	Yes	1	0	1	Not calculated
Kuhlia rupestris (Lacepède, 1802)	Diurnal	No	8	12	10	Not calculated
Macrobrachium sp.	Nocturnal	No	20	6	111	Not calculated
Stiphodon semoni Weber, 1895	Diurnal	No	1	0	1	Not calculated
Sicyopterus spp. (*S. cynocephalus* + *S. lagocephalus*)	Diurnal	No	1	3	10	5

30-minute search duration was used to compare with the camera network. *Sicyopterus* spp. were only observed in the open (outside crevices) during the first minute of each snorkel survey and did not emerge for the remainder of the survey. Photographs were taken of species in crevices with the aid of dive torches if necessary.

Snorkellers were also able to confirm that at least two male *S. cynocephalus* were present in the pool by simultaneously observing an individual in a crevice and another in open water. Female *Sicyopterus cynocephalus* in crevices were identified based on their diagnostic red eye colour and were also sometimes observed on video. However, there were multiple occasions where individual *Sicyopterus* could not be identified to species level during snorkel searches or video processing.

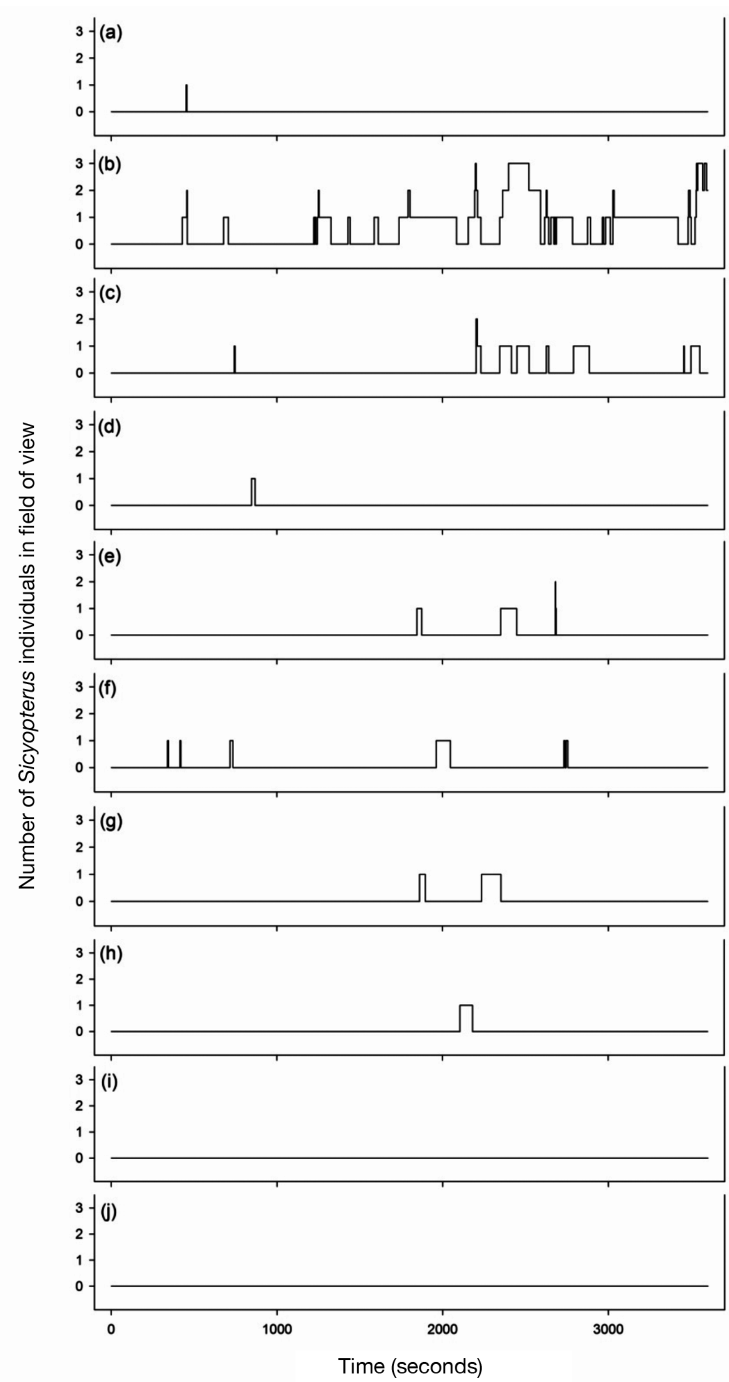

Figure 3. – Number of *Sicyopterus* spp. observed at a second-by-second resolution on each of ten video cameras (a-j) based on a one-hour deployment in the field on 18 September, 2014.

Animal behaviour

Direct observations and video records revealed a large male *S. cynocephalus* frequently in deeper water (0.5-2.0 m) on boulder-rock slabs positioned toward the anterior middle-right bank (facing downstream) of the plunge pool. This individual was frequently grazing on large boulders and bedrock, and was vigilant in chasing off female *S. cynocephalus* and both male and female *S. lagocephalus*. A second, larger male *S. cynocephalus* was also repeatedly observed in a deep narrow crevice within an open cave (Fig. 2C) and did not appear to be nesting. The two large males were not recorded simultaneously in the open and it is possible that an antagonistic relationship existed between these individuals. Furthermore, smaller *Sicyopterus* spp. were typically observed in interstices (Fig. 2D, E). The observer effect appears to extend to video cameras based on preliminary insight from figure 4. Specifically, overall *Sicyopterus* counts appear to be higher in the second 30 minutes compared with the first 30 minutes of filming.

DISCUSSION

Sicydiine biogeography and conservation

This paper confirms the first record of *S. cynocephalus* in Australia. This report adds to the growing list of Sicydiine gobies found in the Australian Wet Tropics, with most records coming from short-steep-coastal-streams (Allen *et al.,* 2002; Ebner and Thuesen, 2010; Ebner *et al.,* 2011; Thuesen *et al.,* 2011). The sicydiine species discovered in Australia to date are either widely distributed in the central tropical Pacific or at least shared with islands of the South Pacific (Thuesen *et al.,* 2011; Keith *et al.,* 2015). It is doubtful that *S. cynocephalus* is self-sustaining in Australia given its amphidromous lifecycle. Also, substantial survey effort has revealed its occurrence in only one stream. Fortunately, the species receives some level of protection, at least

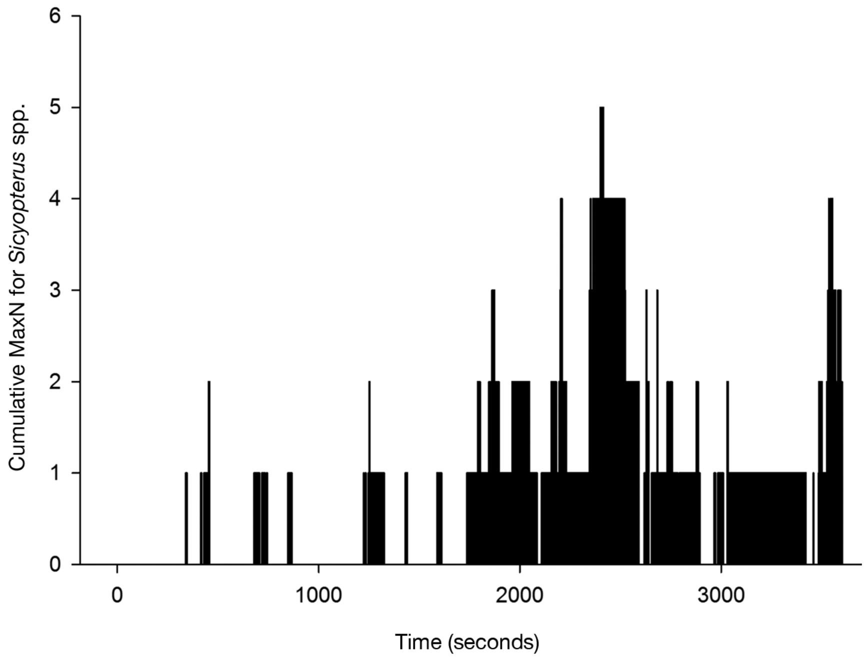

Figure 4. – Cumulative number of *Sicyopterus* spp. in view at any one time during the recording period across the ten cameras (*i.e.* NetworkN) deployed on 18 September, 2014.

theoretically, because cling gobies are currently protected under Queensland legislation.

It is also worth mentioning the relatively large size of the two male *S. cynocephalus* encountered in the current study. Estimated at 180 and 200 mm TL, respectively, these individuals are considerably larger than previous records for this species (110 mm SL) (Keith *et al.*, 2015) and considerably larger than the size previously reported for *S. lagocephalus* (typically less than 130 mm TL; Allen *et al.,* 2002; Marquet *et al.,* 2003; Ebner *et al.,* 2011). In time it may be useful to use stereo video (*e.g.* Harvey *et al.,* 2002) to verify the size structure of this species taking care to film in a range of habitat types, as there is a possibility that large dominant males are found in difficult to sample locations based on the wider experience of the authorship team.

Visual survey techniques

The current study utilised a number of visual techniques for detecting and counting an elusive fish species. It also demonstrates the value of combining snorkel surveys, remote cameras and manual photography methods. Snorkelling was effective for initially finding *S. cynocephalus* (likely a large male in brown form), in searching for it elsewhere within the stream, in photographing an individual (a large white form male) and for strategic placement of video cameras. It proved too elusive to photograph when first encountered, but a large male was eventually photographed on the second day. Remote video cameras were also useful for obtaining both still frames and moving images of the species, and proved essential for confirming the presence of the highly elusive females. This experience confirms the value of using multiple survey techniques for sicydiine gobies such as *S. cynocephalus* in plunge-pool habitat. In addition to the obvious advantages for studying general behaviour, this study emphasizes the utility of in-stream videography for species identification in the absence of voucher specimens (McKelvey *et al.*, 2008). The latter is particularly important in the Australian context where the sicydiine goby assemblage (Ebner and Thuesen, 2010) is often represented by very few, often elusive individuals, and therefore it is not always practical to capture voucher specimens.

The current study also provides an opportunity for comparison of snorkel-searching versus remote cameras for detecting *Sicyopterus* individuals. Our results indicate that snorkelling was best for counting the number of *Sicyopterus* individuals compared with a ten-camera network. However, the video network was superior for detecting females of *S. cynocephalus*, which proved too shy and elusive for snorkel observation. The results, although very preliminary at this stage, indicate considerable promise in combining a camera network with more traditional observational methods. Nevertheless, it would be desirable to further compare camera networks versus more traditional methods (*e.g.* active searching by snorkel, electrofishing) across a greater range of variables, including different gobiid taxa, different stream habitats (*e.g.* plunge pools, riffles, runs, pools), and different times of the year (with emphasis on water levels and incidence of nesting) in order to formulate the most efficient approach for specific conditions. From a practical perspective, snorkel-searching provides a rapid, highly-mobile technique that works well for detecting rare and elusive species at both reach and entire catchment scales for small streams in tropical rainforests (Ebner and Thuesen, 2010; Thuesen *et al.*, 2011; Fulton *et al.*, 2012; Ebner *et al.,* 2015). In contrast, camera networks show great promise for more detailed observations of elusive species (*e.g.* overall counts and behavioural study) after subjects are located by snorkelling or when their presence is anticipated at specific locations or in habitats that are difficult to sample (Fulton *et al.*, 2012).

Previous studies (Thuesen *et al.,* 2011; Ebner *et al.,* 2015) have emphasised the major advantage of having greater mobility when utilising snorkel searches at the catchment level in steep-gradient streams, which are typical of coastal/rainforest habitat in north-eastern Queensland. In contrast, the current study explores a methodology that is more localised in application, in this case, a single plunge pool at the base of a small waterfall. This habitat is a common feature of steep tropical streams and observations are sometimes compromised by water depth and turbulence, preventing certain techniques such as backpack electrofishing or effective snorkel searches.

Animal behaviour

That a large male *S. cynocephalus* frequently grazed on large boulders and bedrock, and was vigilant in chasing off female *S. cynocephalus* and both male and female *S. lagocephalus* is interesting in part because of the sheer size of the aggressor relative to sicydiine gobies typically encountered in the Australian Wet Tropics (*cf.* Ebner and Thuesen, 2010; Ebner *et al.,* 2011). Detailed behavioural studies of sicydiine gobies within pools have revealed similar territorial behaviour whereby by large males occupy vantage points and guard and graze large rock surfaces in pools (Fitzsimons and Nishimoto, 1990; Fitzsimons *et al.*, 2003). This behaviour in turn has implications for bias in male-female and species counts by active search and the network camera methods.

Previous studies have relied on snorkel-searching for nests and rock turning to identify spawning sites and associated parental care in stream gobies (*e.g.* Maeda *et al.*, 2008). It should prove more informative to supplement these activities with careful placement of fixed infrared cameras. This combined methodology holds great promise (*cf.* Butler and Rowland, 2009) for thoroughly documenting parental care in amphidromous stream gobies such as *S. cynocephalus*, which appear to be highly territorial. It would also be informative to determine if the interspecific behaviour of the stream fauna is altered during periods when males are guarding nests. Existing observations of territorial stream fishes (*e.g.* Nakano, 1995) provide a template that can certainly be enhanced with networks of miniaturized cameras (Holbrook and Schmitt, 2002; Butler and Rowland, 2009; Ebner *et al.*, 2009; Struthers *et al.*, 2015). Filming for substantially lengthier times than one hour should be used in behavioural studies and to estimate any observer effect in future applications centred on *Sicyopterus* species.

The current study provides promising evidence of the capability of a remote video network for rapid surveillance of stream fishes over a short time period. The next logical step would be to create a multi-camera video network with substantially longer-term surveillance capacity. The methodology for such networks currently exists for single or a small number of cameras (*e.g.* Aguzzi *et al.,* 2011; Ponton *et al.,* 2012), however, video surveillance at much greater temporal extent presents a new set of challenges, including the need for greater storage capacity and quicker video processing. In order to view the behaviour of elusive stream gobies such as *Sicyopterus* species, which are exclusively diurnal, but alternate between sheltering in interstices and grazing in open spaces, a complement of infrared cameras focused on shelters and rotating cameras deployed in open areas (*e.g.* Mallet *et al.*, 2014) may prove optimal.

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