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1 Lay Summary

Tried and true or in with the new may all depend on spatial scale in home-hunting frogs.
Animals use two information sources when making decisions: prior information from
instinct or experience, and current information gathered in the moment. Our experiment
suggests frogs use prior information when choosing nest-sites at broad scales, but
switch to current information as the search refines. Thus, spatial scale may play an
important role in how individuals process information.

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8 Reduction in site-fidelity with smaller spatial scale may

9 suggest scale-dependent information use

10 Running Title: Site-fidelity and spatial scale

Animals change the strategy that they use to select breeding sites at the spatial scales of habitat, patch and microhabitat. In this regard, breeding site-fidelity is expected to vary according to environmental predictability, which, in turn, is expected to differ between each spatial scale. However, whether or not animals change their degree of site-fidelity at different spatial scales remains unclear. We captured and released males of the terrestrial frog *Pseudophryne bibronii* into alternative patches within a breeding habitat and determined the extent to which site-fidelity influenced individual nest-site choice. We found that males tended to return to their original patch rather than re-settle in an alternative patch. However, males were unlikely to return to their original nest-sites within the patch. We suggest that site fidelity in this species may be scale dependent because information from previous breeding seasons can predict the quality of patches, but not nest-sites. This behavioural variation is consistent with a hypothetical relationship between spatial scale and environmental predictability, which may have important implications for decision making processes that extend over multiple spatial scales.

Key-words habitat selection, current and prior information, spatial and temporal
scale, uncertainty, site-fidelity, breeding behaviour, anuran

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31	Oviparous animals choose the best available habitat in which to lay their eggs
32	(Fretwell and Lucas 1970; Calsbeek and Sinervo 2002; Refsnider and Janzen 2010),
33	with decisions depending on environmental cues that indicate an area's reproductive
34	suitability (Krebs 1971). Furthermore, individual responses to these cues can be scale-
35	dependent. For instance, yellow headed blackbirds (Xanthocephalus xanthocephalus)
36	choose breeding sites based on assessments of food productivity at broad spatial scales,
37	but vegetation density at finer scales (Orians and Wittenberger 1991). Because available
38	cues can never completely predict the environment, animals often develop adaptive
39	responses to the inherent level of uncertainty. However, it is unclear how animals adjust
40	breeding-site decisions in relation to environmental unpredictability at different spatial
41	scales, despite this process being crucial for understanding habitat selection (Lima and
42	Zollner 1996; Schmidt, Dall, and van Gils 2010; Schmidt and Whelan 2010).
43	One way animals can reduce uncertainty in their decision making is by
44	expressing stereotyped behavioural or physiological responses to specific environmental
45	triggers, or by using information from previous experience (Switzer 1993; Maynard
46	Smith 2000; Wagner and Danchin 2010). In many cases, 'prior information' allows an
47	individual to exploit patterns that are predictable over time. However, continued
48	exploitation of a pattern on the basis of prior information is vulnerable to changes in the
49	environment. Individuals can instead benefit by updating their information through
50	exploration of their environment, although gathering 'updated information' comes at a
51	cost (Dall and Johnstone 2002; Dall et al. 2005; Dall 2010). The optimal response to the
52	trade-off between the use of prior and updated information is partly determined by the
53	predictability of the environment (Gould 1974; Stephens 1989; Mangel 1990; Dall and

Cuthill 1997; Luttbeg and Warner 1999; Dall et al. 2005). In this respect, a decrease in 54

55 predictability is expected to reduce the benefits of using prior information in relation to 56 updated information because previous experience has less relevance to current 57 conditions.

Environmental predictability varies across different spatial scales, and information use is expected to vary accordingly. There are at least two mechanisms that could generate scale-dependent information use. First, the timescale of environmental and ecological patterns and processes are longer at larger spatial scales (Wiens 1989). Thus, prior information may provide a better basis for adaptive decisions at larger spatial scales than smaller spatial scales, as previous conditions can serve as an adequate approximation for the current state. Second the predictive ability of prior information can decrease at smaller spatial scales because it becomes more difficult to build dynamic models (e.g. behavioural assessment and response) as the scale being considered decreases (Costanza and Maxwell 1994). This trend arises because the uncertainties involved in small scale components can be averaged out when they are considered at larger scales. Therefore, we can hypothesise that the use of prior information will decrease, and the use of updated information will increase, at smaller spatial scales.

We can study the use of prior and updated information through the expression of site-fidelity, in which an individual is faithful to a previously used breeding-site over multiple breeding attempts (Burger 1982; Switzer 1997; Ringler, Ursprung, and Hödl 2009). Site-fidelity may allow individuals to use prior information from previous breeding attempts to exploit predictable conditions. However, continued exploitation of the same site can result in lost opportunities for finding better quality sites. Individuals can instead invest in updated information by exploring whether a superior site exists

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79	(Johnson and Gaines 1990; Switzer 1993; Switzer 1997; Doligez et al. 2003; Piper
80	2011). If an animal's decision to be site-faithful can be scale dependent, this would
81	suggest that individuals adjust their decisions to the level of uncertainty at a given
82	spatial scale. However, many studies of breeding site choice base their conclusions on
83	patterns of distribution and abundance, and are unable to separate the decision to be
84	site-faithful from coarse ecological processes (e.g. resource limitation, competition) that
85	could also result in the re-use of nest sites (Parrish and Edelstein-Keshet 1999; Doligez
86	et al. 2003; Boulinier et al. 2008). Thus, manipulative field experiments that distinguish
87	between pattern and process will enable us to determine whether site-fidelity varies with
88	spatial scale.
89	We performed a novel patch-swap experiment on an entire male population of

we performed a novel patch-swap experiment on an entire male population of the terrestrial toadlet *Pseudophryne bibronii*, and measured site-fidelity during resettlement. Our aim was to determine if individuals choose to be site-faithful if they are presented with the opportunity to settle in an alternative breeding site. Following resettlement, we compared the use of site-fidelity at different spatial scales to determine if there was a decrease in site-fidelity at smaller spatial scales.

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- 96 Materials and methods
- 97

98 Study species

99 The brown toadlet *Pseudophryne bibronii* is a Myobatrachid frog that is
100 endemic to temperate regions of south-eastern Australia (Tyler and Knight 2009). *P.*101 *bibronii* are terrestrial breeders, with males entering breeding sites at the beginning of
102 autumn and establishing shallow burrows in moist soil underneath leaf litter in dry creek

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103	lines and drainage pans. Males advertise their presence to females and mediate
104	competitive interactions with acoustic signals (Pengilley 1971; Woodruff 1976;
105	Mitchell 2001; Byrne 2008; Heap, Stuart-Fox, and Byrne 2012; Heap and Byrne 2013).
106	Females oviposit directly into the burrow, after presumably assessing the quality of the
107	nest-site and/or the resident male (Pengilley 1971; Woodruff 1976; Byrne and Keogh
108	2007; Byrne and Keogh 2009). Females are extremely polyandrous and sequentially
109	split their clutch amongst the nests of two to eight males (Byrne and Keogh 2009; Byrne
110	and Roberts 2012). Consequently, around 80 percent of the males in the chorus can gain
111	mating success (Byrne and Keogh 2009). Typically, males remain with their eggs over
112	the course of the breeding season, which continues until winter rainfalls inundate the
113	habitat and eggs hatch into ephemeral pools. Heavy rain events that temporarily flood a
114	nest-site often lead to its abandonment, at which point males either establish a new nest
115	in an area that hasn't flooded, return to their original site after waiting for the water to
116	recede, or leave the chorus entirely. Such displacement can happen several times a
117	season (approximately 2-4 times) before the site remains flooded and toadlets establish
118	a new nest or leave altogether (P.G. Byrne, unpublished data). Males may or may not
119	provide some level of care for their eggs (Woodruff 1977). There is also evidence for
120	alternative reproductive strategies, including males fertilising eggs in other nests and
121	maintaining multiple nest-sites (Mitchell 2005; Byrne and Keogh 2009). Between
122	seasons toadlets move into the bush surrounding the breeding site and overwinter under
123	rocks or logs, and males are likely to experience at least five separate breeding seasons
124	over their lives (P.G. Byrne, unpublished data).
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126 Field protocol

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127	The patch-swap experiment was performed on a population of toadlets in Bream
128	Beach, Australia, between 19 April and 20 May 2010. We divided the breeding habitat
129	into three distinct patches, referred to as the north, east and south patch, based on the
130	intersection of two ephemeral streams (Figure 1). We collected every calling male in
131	each patch approximately 4-6 weeks after the commencement of a 3-4 month breeding
132	season. Collections were made over three consecutive nights, with toadlets captured
133	from the north patch on night one $(19/4/2010; n = 13 \text{ males})$, the east patch on night two
134	(20/4/10; n = 23 males), and the south patch on night three $(21/4/10; n = 16 males)$. At
135	the time of collection, nest sites were marked with an ID flag and males were placed
136	into plastic zip-lock bags and transported to a field station (located approximately 1km
137	from the study site), where they were then housed in individual plastic containers (175 x
138	125 x 50mm). Containers each held a moist sponge to ensure frogs remained fully
139	hydrated and were kept in a room with windows that permitted frogs to receive natural
140	light: dark cycles. On the day after collection frogs were weighed using a digital balance
141	and photographed. Because P. bibronii have unique individual ventral patterns, the
142	photographic identification method (PIM; Bradfield 2004; Mitchell 2005; Kenyon,
143	Phillott, and Alford 2009; Kenyon, Phillott, and Alford 2010) provided a reliable and
144	unambiguous form of identification (identifications conducted by SMH and PB).
145	We aimed to test the expression of patch-fidelity by comparing the fidelity of
146	individuals placed in an alternative patch with those placed in their original patch. We
147	kept each group of males at the field station for two nights in order to temporally
148	dislocate them from their original site selection attempt. Males from the north and east
149	patches were randomly chosen to be used in the patch-swap treatment, whereas males
150	from the south patch were chosen as a control. We released north males into the east

151	patch, east males into the north patch and south males into the south patch on three
152	successive nights (21-23/4/10). We released males at a centralised location within their
153	release patch (Figure 1), which was 23±11m from their original capture site. Prior to
154	release, we arranged containers into a circle, with lids facing outwards, and after 5
155	minutes of acclimation opened each lid. Exactly 29, 30 and 31 days after the initial
156	collection we re-captured calling males from the north ($17/5/10$; n = 11), east ($18/5/10$;
157	n = 17) and south (19/5/10; $n = 12$) patches, respectively. We repeated the procedure of
158	the original capture and used the photographic identification method (PIM) to identify
159	the occupant of each nest site. Three new frogs were captured during this second
160	capture period, but were not included in analyses as they were not part of the
161	experiment. We laid lines of string through the chorus to serve as the axes of a
162	coordinate system and noted the Cartesian coordinates for original and re-settled nest-
163	sites.
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165	Statistical analyses

We considered the expression of site fidelity at the patch scale by using Fisher's tests to determine whether the proportion of males that settled in their release patch differed between treatment groups. Additionally, we explored the occurrence of site fidelity at the nest-site scale and the change in site-fidelity between scales by using chi-squared tests to determine the proportion of males that returned to i) their original patch (patch-fidelity), ii) their original nest-site (strict site-fidelity) and iii) within 1m of their original nest-site (coarse site-fidelity). We calculated the 95% confidence intervals at each scale and inferred whether there were any changes across scales by considering whether the confidence intervals were overlapping.

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175	We also tested for patch-fidelity by considering the directions and distances
176	travelled by males following displacement in relation to their original nest-sites, under
177	the hypothesis that these values will be similar if patch-fidelity was being expressed.
178	Specifically, we tested whether the distance each male travelled was equivalent to the
179	distance it was displaced by using linear regression and paired t-tests, analysing the
180	males of each patch separately. The direction of travel was analysed using a Hotelling
181	test, following the guidelines of Zar (1999). This test can determine whether there is a
182	significant difference between the azimuths of a male's original and re-settled nest-sites
183	(using the release site as the reference point). As a check on our methodology, we also
184	tested whether there was any linear relationship between an individual's change in nest-
185	site location (i.e. the distance between its original and resettled nest-site) and the
186	distance that it was transported to the release site from its original nest-site.
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188 **Results**

189 We first determined whether males expressed fidelity at the patch scale. The 190 frequency of males that settled in the release-patch depended on the treatment (Fisher's 191 test: p < 0.001; Table 1). Specifically, males from the control were significantly more 192 likely to re-settle in the release patch than males from the patch-swap treatment 193 (Fisher's test: p < 0.001; Table 1). This analysis included twelve males that were not re-194 captured, who were classified as not having re-settled in the release patch. Furthermore, 195 the distances from the release site to original and re-settled nest-sites were strongly correlated for the control males ($F_{1, 10} = 10.63$, $r^2 = 0.47$, p = 0.001) and those captured 196 from the east patch (F_{1, 15} = 92.79, r^2 = 0.85, p < 0.001). In comparison, there was no 197 significant correlation for males collected from the north patch ($F_{1,9} = 0.02$, $r^2 < 0.01$, p 198

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199	= 0.901). However, paired t-tests indicate that there were no significant differences
200	between displacement and travel distances for males collected from the south (t_{11} =
201	1.71, p = 0.116), east (t_{16} = 0.37, p = 0.719) or north patches (t_{10} = 0.83, p = 0.425).
202	Additionally, the direction males travelled after release was not significantly different
203	from the direction of their original nest-site (Figure 2) for males from the south ($F_{2, 10} =$
204	1.96, p = 0.191), east ($F_{2, 15} = 0.50$, p = 0.618) or north ($F_{2, 9} = 0.43$, p = 0.665). Thus, it
205	appears that the scale of resettlement is equivalent to the scale of displacement. The lack
206	of correlation between the distances for the northern males may be due to the small
207	patch and sample sizes.
208	We then considered changes in the expression of site fidelity between spatial
209	scales by comparing the proportions of individuals that re-settled in the same spatial
210	location at each scale. We only considered the forty males that re-settled for this
211	analysis, as we were interested in whether the males that decided to re-settle were site-
212	faithful or not. There were no significant differences in the proportion of individuals
213	that settled in their original patch between the three treatment groups (Fisher's test: $p =$
214	0.739), or between the control and pooled patch-swap treatment groups (Fisher's test: p
215	= 1.000). Thus, we pooled males from all three treatment groups together to consider
216	patch-fidelity. Overall, 38 of the 40 recaptured males (95%) were found in their original
217	patch (Figure 1, 3; Table 2). We are 95% confident that the proportion of males that
218	express patch-fidelity lies between 82 and 99% when all males are pooled (Figure 3,
219	Table 2).
220	By comparison, only 3 of the 40 males (proportion: 0.08; 95% CI: 0.02 - 0.21)
221	that held a nest-site decided to re-settle at the same nest location (strict site-fidelity;

Figures 1, 3; Table 2). Even if the criterion for site-fidelity is relaxed to 1m surrounding

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223	the original nest site (coarse site-fidelity), only eight individuals (proportion: 0.20, 95%
224	CI: 0.10 - 0.36) expressed site-fidelity (Figures 1, 3; Table 2). There were significant
225	differences in the proportions of males that expressed strict site-fidelity (Fisher's test: p
226	= 0.017) and coarse site fidelity (Fisher's test: $p = 0.030$) between treatment groups.
227	Specifically, χ^2 components indicate that nest-site fidelity was more common for males
228	that were collected from, and re-settled within, the northern patch (Table 2).
229	Comparison of each patch separately indicates that site-fidelity decreased between the
230	patch and nest-site scale for males from the southern and eastern patches, but not for
231	males in the northern patch (Figure 3).
232	Importantly, there was no significant correlation between an individual's change
233	in nest-site location and the distance of the release site from its original nest-site (linear
234	regression: $F_{1,38} = 0.06$, p = 0.803, r ² < 0.01), indicating that lack of nest site-fidelity
235	was not because males were released too far from their original nest site to be able to
236	return. In general, males re-settled in a nest-site not encountered during the original
237	survey and capture (presumably having constructed a new burrow). However, there
238	were a few exceptions. First, two pairs of individuals were found within a single nest
239	upon recapture, with one of these individuals having expressed site-fidelity. No eggs
240	were found in this nest. Second, one individual was found in a nest-site that was
241	inhabited by another during the original capture. Again, this nest did not contain any
242	eggs. The original resident had a new nest 2.5m away, and the new resident was found
243	3.2m from its original nest. Third, four original nest-sites appeared to have been
244	occupied for some period during re-settlement, but were unoccupied at the time of
245	recapture. This was determined by measuring the occurrence of calling activity during
246	the re-settlement period as part of a related study (Heap and Byrne 2013). Although the

identity of the callers could not be determined, the original occupants of these nests
were found 1.2m, 1.8m and 9.3m away from their original site by the end of the study.
The fourth male was not recaptured. Finally, there were three males that were
recaptured in their original nest-site. There were nests before and after capture that
contained eggs, and we have analysed the presence of eggs in another study (Heap and
Byrne 2013). This analysis found no correlation between nest-site location and egg
presence, or any correlation between breeding success before and after re-settlement.

Discussion

Males showed a strong preference for their original patch over an alternative patch. Furthermore, males moved in the direction of their original nest-sites following release and travelled an equivalent distance to that of displacement to reach a new nest-site. Together, these results imply that males display site-fidelity at the patch scale. In contrast, relatively few males returned to within one metre of their original nest-site. Additionally, males appear to be aware of the location of their original nest-site, judging by the direction and distance of movement after release, yet they do not tend to re-settle in the same location. Thus, these results suggest that the expression of site-fidelity for choosing breeding sites may be scale dependent (Figure 4). That is, returning to familiar patches may improve reproductive success, but fidelity to nest-sites may provide little additional benefit. However, changes in the expression of site-fidelity with spatial scale appeared to depend upon the patch that males were captured from because we can not be confident that the males that re-settled in the north patch showed an equivalent decrease in site-fidelity at smaller spatial scales compared to the east and south patches.

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270	Breeding habitat selection involves responding to information that predicts
271	reproductive success at multiple spatial scales. Previous studies have shown that the
272	cues that allow reliable assessment of site quality can vary with spatial scale (Krebs
273	1971; Orians and Wittenberger 1991). Our results suggest that the general manner in
274	which information is used can also vary between spatial scales. In particular, if we
275	consider site-fidelity to indicate the use of prior information, and occupation of new
276	sites to indicate the use of updated information (Johnson and Gaines 1990; Switzer
277	1993; Switzer 1997; Doligez et al. 2003; Piper 2011), then our results suggest that the
278	nature of information used to choose nest sites varies with spatial scale. Specifically,
279	male P. bibronii may benefit from using prior information when choosing patches, but
280	benefit from responding to updated information when choosing nest-sites within the
281	patch (Figure 4).
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These results conform to theory that predicts the value of prior information (in terms of the net benefit that responding to the information would provide) to increase as spatial scale increases, whilst the value of updated information to increase as spatial scale decreases (Wiens 1989; Costanza and Maxwell 1994; Figure 4). In the case of toadlets, flooding patterns are an important factor in determining reproductive success (Woodruff 1976; Bradford and Seymour 1988; Geiser and Seymour 1989; Byrne and Keogh 2009), and variation in flooding patterns at different spatial scales may partly explain why the value of prior information is greater at the patch scale than the nest-site scale. Patches in this system occur around ephemeral bodies of water such as streams and ponds. The climatic and topographical patterns that allow these bodies to exist may be predictable across years, such that an individual can be relatively certain that a similar body will exist in the current season based on its existence in a previous season.

294	However, whether or not a given nest-site floods to an appropriate level is likely to be
295	more variable (less predictable) between years than the presence of a suitable body of
296	water in the patch due to fine scale differences in drainage patterns over space and time.
297	Thus, prior information may be reliable at the patch scale but not at the nest-site scale.
298	This notion could be tested by measuring reproductive success at nest sites over
299	multiple years, with the prediction that variation in the average patch reproductive
300	success across years is less than variation at a given nest site. Additionally, the
301	hydrodynamic properties of the substrate can be measured and compared between years.
302	The lack of site fidelity at the nest-site scale suggests that males must gather
303	information on their current surroundings to find a suitable nest site within the patch. In
304	this regard, males appear to partly respond to information on the local spatial
305	arrangement of other males more than physical properties such as soil moisture when
306	establishing a nest-site (Heap and Byrne 2013). However, such physical properties may
307	influence male calling behaviour, and in turn, spatial arrangements. For example, in a
308	manipulative field experiment in which nest sites were artificially wetted, Mitchell
309	(2001) demonstrated that male <i>P. bibronii</i> call more from wetter nests presumably
310	because there is less risk of desiccation.
311	The response to other males may largely be driven by the need to alleviate
312	competition over acoustic space, as males tend to abandon sites in denser areas (Heap
313	and Byrne 2013). Although there is no apparent correlation between density and
314	breeding success in <i>P. bibronii</i> at these sites during the observed breeding season (Heap
315	and Byrne 2013), the evidence that competition for space is critical in finding mates
316	across frog species is overwhelming (Wells 2007). Competition aside, the previously
317	reported pattern that males have tendencies to avoid isolated and peripheral areas

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318	provides an indicator that uncertainty as to nest-site quality is high within patches (Heap
319	and Byrne 2013). Specifically, this pattern of conspecific attraction suggests that males
320	copy each other's breeding site decisions, and individuals are expected to only prefer
321	using social cues over non-social cues when either i.) the costs of acquiring personal
322	information are too great (i.e. trial and error in reproductive success, coupled with the
323	risk of nest-site failure), or ii.) non-social cues are unreliable or uninformative (Dewar
324	2004; Coolen et al. 2005; Kendel et al 2005). That is, if uncertainty was not an issue
325	within patches then males should perhaps prefer acquiring personal information over
326	using social cues. In any case, the information that males use to choose a nest-site
327	remains an open question. That being said, any evidence that the use of social cues
328	within patches is driven by uninformative non-social cues (rather than the costs of
329	acquiring personal information) would strongly support the hypothesis that there is
330	scale-dependent uncertainty.

331 The higher variance in behaviour of males in the northern patch, who showed a 332 greater average degree of site-fidelity at the nest-site scale than males from other 333 patches, is consistent with this overall explanation. Males in the northern patch mostly 334 settled on the edge of a small pond that floods to the same extent almost every year 335 (P.G. Byrne, personal observation). By contrast, males in the southern and eastern 336 patches settled along the banks of small ephemeral streams that are less consistent in 337 their flooding patterns. Thus, prior information on nest-site quality may be more 338 relevant in the northern patch than the southern and eastern patches, and hence site-339 fidelity more common at the nest-site scale. However, it is important to note that there 340 was greater variance in site-fidelity for northern males, and this could be due to either 341 the characteristics of the patch or the smaller sample size.

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342	There is, however, an alternative explanation to a spatio-temporal scaling
343	relationship underlying changes in behaviour at different spatial scales. Males may have
344	actually gathered information about novel patches and decided that they were unsuitable
345	breeding sites. Males may also have avoided returning to their original nest-site due to
346	experimental handling. Thus, our explanation requires support from experiments that
347	demonstrate prior information is consistently used over current information to select
348	patches, and from a full qualification of the degree to which males show site fidelity at
349	the nest-site scale. These gaps can be addressed by conducting an experiment that tests
350	whether males prefer familiar patches over alternative patches that present more
351	favourable information on quality than the empty patches used in this experiment (e.g.
352	settled patches or evidence of females). Furthermore, an experiment in which males are
353	captured and returned to their original nest-site or returned to another male's nest-site
354	within the same patch can determine if site-fidelity is expressed at the nest-site scale.
355	Finally, a complete understanding of site-fidelity would require observations to be made
356	over multiple breeding seasons.
357	In conclusion, our patch-swap experiment showed that terrestrial toadlets
358	displayed reduced breeding site-fidelity at smaller spatial scales, presumably due to
359	decreased environmental predictability. These patterns are consistent with changes in
360	the use of prior and updated information. A consideration of changes in information use
361	with spatial scale may be important when studying behaviours that take place over
362	multiple scales, such as habitat selection and foraging behaviour. Furthermore, a
363	relationship between spatial scale and the timescale of ecological processes may
364	influence how animals adapt to uncertainty beyond the use of prior and updated
365	information. For instance, the adaptive level of forgetting (Mangel 1990) may be longer

 with regards to cues available at large spatial scales than small spatial scales. Additionally, variation in information use between and within species can have implications for population dynamics and community interactions (Schmidt, Dall, and van Gils 2010). Thus, scaling relationships regarding information use can influence broader ecological patterns. Future research may benefit from considering relationships between environmental predictability and spatial scale as these associations are likely to be critical for developing a theory of ecological information use (Schmidt, Dall, and van Gils 2010).

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487 Figures

Figure 1: Map of the habitat, showing the three patches (north, east, south). Arrows between patches indicate where captured males were released, with a cross representing the release site. The location of each male's original nest (grey circle) and re-settled nest (black circle) are connected by a dotted line. Males that returned to their original nest are represented by a black box. Males that did not re-settle are marked with a grey triangle. The scale in the upper-right is marked at 1m intervals.

Figure 2: The mean angle of original (grey) and re-settled (black) nest-sites in relation to the site of release displayed on a unit circle, for males captured from the southern control, and experimental northern and eastern patches. The length of the vector associated with the mean angle varies inversely with the dispersion of individual nestsite angles, and is thus a measure of concentration in the direction of nest-sites from the release site.

Figure 3: Estimated proportion (symbols) and 95% confidence interval (whiskers) for males expressing patch, coarse and strict site-fidelity for males captured from the southern control (circle; black; n = 12), northern (triangle; light grey; n = 11) and eastern (square; dark grey; n = 17) patches.

507 Figure 4: The hypothesised relationship between spatial scale and the value of

508 information (in terms of the net benefit of responding to the information) for current

509 (solid line) and prior (dashed line) information. Site-fidelity is a response to prior

510 information. As such, superimposed over the curve for prior information are diagrams

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3 4 5	511	of the two spatial scales considered in this study and the frequency of site-fidelity
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Tables

- 515 Table 1: Frequency of individual male terrestrial toadlets (n = 52) that either:
- 516 established a calling site within the patch in which they were released, or moved to a
- 517 different patch.

	control	patch-swap	
settled in patch of release		N→E	E→N
yes	12	0	1
no	4	13	22

519 Table 2: Frequency of re-settled individuals (n = 40) that established their re-settled 520 nest-site in a given location.

		patch-swap		
location	control	N→E	E→N	
original patch	12 (0.03)	10 (0.02)	16 (0.00)	
different patch	0 (0.60)	1 (0.37)	1 (0.03)	
original nest-site	0 (0.90)	3 (5.73)	0 (1.28)	
different nest-site	12 (0.07)	8 (0.46)	17 (0.10)	
< 1m of original nest-site	2 (0.07)	5 (3.56)	1 (1.69)	
> 1m of original nest-site	10 (0.02)	6 (0.89)	16 (0.42)	

 Chi-squared components indicated parenthetically.









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Map of the habitat, showing the three patches (north, east, south). Arrows between patches indicate where captured males were released, with a cross representing the release site. The location of each male's original nest (grey circle) and re-settled nest (black circle) are connected by a dotted line. Males that returned to their original nest are represented by a black box. Males that did not re-settle are marked with a grey triangle. The scale in the upper-right is marked at 1m intervals.

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E -> N

Control

N -> E

The mean angle of original (grey) and re-settled (black) nest-sites in relation to the site of release displayed

on a unit circle, for males captured from the southern control, and experimental northern and eastern

patches. The length of the vector associated with the mean angle varies inversely with the dispersion of

individual nest-site angles, and is thus a measure of concentration in the direction of nest-sites from the

release site. 79x84mm (72 x 72 DPI)







Estimated proportion (symbols) and 95% confidence interval (whiskers) for males expressing patch, coarse and strict site-fidelity for males captured from the southern control (circle; black; n = 12), northern (triangle; light grey; n = 11) and eastern (square; dark grey; n = 17) patches. 78x77mm (600 x 600 DPI)





The hypothesised relationship between spatial scale and the value of information (in terms of the net benefit of responding to the information) for current (solid line) and prior (dashed line) information. Site-fidelity is a response to prior information. As such, superimposed over the curve for prior information are diagrams of the two spatial scales considered in this study and the frequency of site-fidelity expressed by male toadlets. 117x119mm (600 x 600 DPI)

		patch-swap		
site-fidelity decision	control	N->E	E->N	
strict site fidelity	0	3	0	
coarse site fidelity	2	2	1	
patch fidelity	10	5	15	
different patch	0	1	1	
frogs not recaptured	4	2	6	
total frogs	16	13	23	

Frequency of individual male terrestrial toadlets (n=52) that expressed strict,

coarse or patch fidelity. Also included is the frequency of individuals that were not recaptured,

and those that settled in a different patch to the original.

Note that this is not the frequency table that was used for analysis, but a summary.

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