+O(™ J g W 2019, 27 (3): 266–272 doi: 10.17520/biods.2018178
Biodiversity Science http://www.biodiversity-science.net

•.D0¦ Õ z•

Ê+^4Ø L-. p ¦ ¤.J0¬ Þ(Ÿ#q Þ8¸ Á —— µ REœ ¡ ã Ú pTW ˜-$TU2± p Á

G K ‹ [1] ï £ Æ [3] Ï - ì [1,2*]

1 ( ] -0 –L' Ø(™.D0¦ p Ì J<› ãUP ã5, 8"ë*6.D0¦ - æGý&é ÎP¼ Ô, G Ü 100101)
2 ( ] -0 –L' W –, G Ü 100049)
3 (¯ LE– › Ý - æ4×8 'f Ô j , ¯ LN& £ 512500)

Ž?·: Ø(™#k Ø8² » ¼ &L$+O 1 } 6 F _ Ø(™>| j X &L5 Ö,´ 6 3, _) &LCtÀ Y+X,´Gý?± ƒ)à Ä Ø(™#k Ø 8² » `)ß ³ 3P ¼/ýL$ Œ+X,´ ¡ ý, !" , ¶@ Ø(™#k Ø8² » ú &L$+O 1 } 9 Ù ¾ /j5Ô:m ] < 6 3(™/ý &L$Ct$À Y+X,´ 2 ú ¡ ˆ j f ÄF 10 J ¤ •, 4Ò F-( j ° _ X - µ FGþ+O Ø(™- #{.D0¦ ] Ç ` ¯# Ä+X, 0 3_ ¶ WGÿ 9 &L$Aà …,´ Ø(™>| j ž, ± W ` óF ¶ Ø(™#k Ø8² » ¼ &L$+O 1 } 6 F,´$! •.D0¦ Ä \ · ) Ø(™#k Ø 8² ».D0¦ ú Ä+X4Ò F-( j ž.D0¦ Ø(™#k Ø8² »,´ é# F >| ã*6, G÷+X h ö Ö `AÑ é# , Y+X ¯ LE– › Ý - æ 4×8 'f Ô j,´4Ò F-(j- #{ ž, 6 À ¶TQ '- TO2«,´#k Ø8² », L@F …(™/ý ¼ J(™/ý,´#k Ø8² » ú/ýL$ Œ+X) Ø(™ #k Ø8² »,´ ¡ ý Ä.D0¦5 Ì>˜ >E– › Ý Ô j,-Tw(Lophura nycthemera) Ã,--9 ¡T—TZ(Arborophila gingica) ¼& 7(1)TQ(Bambusicola thoracica) 3 ZTQ '- (™/ý {L$ ˆ X = <0; Ö,´1 ¹, (™/ýL$,´ #k Ø8² » x)à]1y0; Ö,´Gý Ä 0 >, J¸) Ø(™#k Ø8² » 6 À é# Ä+X,´ *AÞ ú ¡ ý 3PF >|AØAê, < K j - µ Ø(™#k Ø8² » .D0¦ Ë ò63 Ä

©KdB : #k Ø8² »; 4Ò F-(j; TQ '- ; h ö Ö `AÑ; (™/ý ¡ ˆ; ¯ LE– › Ý - æ4×8 'f Ô j

Application of camera-trapping data to study daily activity patterns of Galliformes in Guangdong Chebaling National Nature Reserve

Lijun Chen[1], Zufei Shu[3], Zhishu Xiao[1,2*]

1 State Key Laboratory of Integrated Management of Pest Insects and Rodents, Institute of Zoology, Chinese Academy of Sciences, Beijing 100101
2 University of Chinese Academy of Sciences, Beijing 100049
3 Guangdong Chebaling National Nature Reserve, Shaoguan, Guangdong 512500

Abstract: Animal activity patterns and temporal niches can indicate the distribution of animal behavior and the utilization resources over time. Environmental variables and interspecific interactions have important effects on animal activity and temporal niche partitioning. These two factors in turn can help understand mechanisms of niche partitioning among sympatric species as well as species coexistence and community composition. Due to the extensive use and deployment of infrared cameras for nearly a decade, a large amount of time-recorded behavioral data has been accumulated. These data are conducive to studying activity rhythms and temporal niches in depth. In the present paper, we reviewed research on animal activity using infrared cameras in combination with in situ monitoring data from the Guangdong Chebaling National Nature Reserve to better understand three Galliformes species. A kernel density was used to estimate the activity and interspecific effects of a single species as well as for multispecies activity. Our study reveals a moderate overlap among Galliformes species, Lophura nycthemera, Arborophila gingica and Bambusicola thoracica, which may be caused by interspecific competition. We discuss the limitations of daily activity analyses to

f0o O: 2018-06-26; Õ O: 2018-10-26
*H N©- : - æGý&é.D N©- (2017YFC0503802; 2016YFC0500105)Ã)] -0 –L'+O(™ J g W- #{ >.D0¦5•5 -2« J g W- #{5•F >|4ÿCi Ã] - Š >0 – *H (2017M620905) Ã2017 ¤] ^ Ç J iM™ …CtH ¼ 2016 ¤] ^CR o Ç J>• ÙCtH
* FJAß Œ65 Author for correspondence. E-mail: xiaozs@ioz.ac.cn

H +U Þ(Ÿ4Ø L-. p ¦ ¤ < Æ IÑÎ

give a reference for similar research.
Key words: daily activity pattern; infrared camera; Galliformes; kernel density estimation; species coexistence; Guangdong Chebaling National Nature Reserve

F 10 J ¤ •, 4Ò F-(j ° _ X - µ FGþ+O Ø(™ - #{.D0¦] Ç ` ¯# Ä+X, 0 3_ ¶ WGÿ 9 &L$Aà … ,´Gþ+O Ø(™>| j ž, ± W ` óF ¶Gþ+O Ø(™,´#k Ø8² » ¼ &L$+O 1 } 6 F,´$! •.D0¦(O'Connell et al, 2011; 6Æ"ë _1y, 2014; Steenweg et al, 2017)Ä !" , ¶@ ¼ ¼ Ø(™#k Ø8² »,´ 6 À é# 6 9 Ù ¾ /j5Ô:m] < 6 3(™/ý X &L$ Ã0ªL$,´ Y+X 2 ú ¦ ¡ ˆ j f(Ridout & Linkie, 2009; Rowcliffe et al, 2014; Dominoni et al, 2017)Ä

- }, - F Ä+X4Ò F-(j ž 0 … Ø(™#k Ø8² »,´.D0¦ J h ö Ö `AÑ é# (kernel density estimation)6 À j k, +X ¾ ÿF …(™/ý ¼ J(™/ý,´ #k Ø8² » úGý 0; Ö(Ridout & Linkie, 2009; Oliveira-Santos et al, 2013; Rowcliffe et al, 2014), ?±2«5Ô 5 Lv+O * £ Ø(™ ¼ ` F WTO2«1y(Bridges & Noss, 2011)ÄLv+O * £ Ø(™ k?± 5 O 6¹2«(Di Bitetti et al, 2010; Monterroso et al, 2014)Ã 9Dt2« (Ferreguetti et al, 2015)Ã žU¯2«(Meek et al, 2012)¼ &¥K¯2«(Gerber et al, 2012)TO2« TQ '- j k(Li et al, 2010)ÄG÷+X4Ò F-(j ž 6 À Ø(™#k Ø8² »,´ .D0¦ "4ÿAñ Î < 6 3(™/ý,´ &L$+O 1 } 6 F _ (™/ý0c Ê ¡ ˆ,´ k?± j f { 0(Ridout & Linkie, 2009; Di Bitetti et al, 2010; Monterroso et al, 2014; Sunarto et al, 2015)Ä » ², < 6 3,´5¾#bB© (Panthera onca)¼5¾#b) (Puma concolor)1y6/ý)[0 Ø(™ § 9 = <,´#k Ø8² », ' 1-(l,´K¯ n<~)[(Leopardus wiedii)¼5¾#b ¡)[(Puma yagouaroundi) 6 [j L>| W ¼ l>| W, ¦ (™/ý j ˜ ? W, #k Ø Q &L$ (™/ý ƒGý = <6< = <(Di Bitetti et al, 2009)Ä

- µ O ¯+X4Ò F-(j.D0¦ Ø(™ #k Ø8² » ,´.D0¦)B' j jUP(Niviventer coxingi)(Pei, 1995) Ã)E)d(Macaca mulatta) ÃU\)®(Melogale moschata)¼ ; 7©Tw(Lophura swinhoii)(?$ æPÀ, 1998)Ã `21 F4Ú } 10 ¤ , .D0¦,´ Ø(™2«5Ô ¼/ý2«F@$@ Î Đ, ? &¥)[(Viverricula indica) Ã8áM')((Paguma larvata)Ã O >))¤(Herpestes urva)¼U\)®(Chen et al, 2009)Ã • @ 5Ê(Budorcas taxicolor, ~ > ü1y, 2011) ú>pLù

(Ithaginis cruentus)¼4Ò7©@ LÜ(Tragopan temminckii) 1yTQ '- TO2«(Li et al, 2010)ÄF 5 ¤ • , 4Ò F-(j ° _ X A - 44×8 'f Ô j,´Gþ+O Ø(™ J g W- #{ .D0¦] Ç ` ¯# Ä+X(Li et al, 2010; ~ •1y, 2014; 6Æ"ë _1y, 2014, 2017)ÄÄ+X4Ò F-(j.D0¦ #k Ø8² »,´ Ø(™/ý2« XEõFO Î Đ(Lt …1), ² * £ Ø(™],´ J nBš)Z(Atherurus macrourus, $Y0û 91y, 2016)Ã PœTC(Cervus elaphus, Lx*K1y 2017) Ã:É à"ã)((Caster fiber birulai, H Ü 1y, 2015) Ã ž"?GþPœ (Equus przewalskii, d ¥1y , 2017)Ã Ê#b))®(Meles leucurus)ÃZ)® (Arctonyx collaris)ÃB©)[(Prionailurus bengalensis)ÃB¹(Nyctereutes procyonoides)Ã] ~ Á 5Ê(Naemorhedus griseus)¼Gþ)Z(Sus scrofa)(Cn ƒ L 1y, 2014;)»K¯£1y, 2015; P$À1I1y, 2017),TQ ' - 5 4Ò7©KVTQ(Chrysolophus pictus, H ? ¼1y, 2017)Ã,- ÐK¯ nLù (Syrmaticus reevesii, C¥)¹#-1y, 2013)¼,-Tw(Lophura nycthemera, ‰ * £1y, 2017) 1y Ä m1Ñ - µ * ¾4Ò F-(j ž 0 … Ø(™#k Ø8² » .D0¦,´2«5Ô XF@$@ Î J, v W J .D0¦ _) 42«5Ô Ø(™#k Ø8² »,´ ÿF W 6 À, 6<FJE÷#k Ø8² » • Ò AØ5Ô:m µ(™/ý ¡ ˆ,´ Œ+X j f,´.D0¦ ý-( )E³ A (Li et al, 2010; Bu et al, 2016)Ä

\ · ¯LE– › Ý - æ4×8 'f Ô j (;1° 0 E– › Ý Ô j) ,-Tw Ã,--9 ¡T—TZ(Arborophila gingica) ¼& 7(1)TQ(Bambusicola thoracica) j.D0¦)B', G÷+X h ö Ö `AÑ é# ," E³ 6 À3 /ý1 ¹(™ /ý {L$,´#k Ø8² » ú ¦Gý 0; Ö, L@F …(™/ý ¼ J(™/ý,´#k Ø8² » ú/ýL$ Œ+X)(™/ý#k Ø8² » ,´ ¡ ý Ä

1 † Ï D ï#

1.1 .J0¬ f&ï ¦ ¤GýLü

E– › Ý Ô j } ¾ ¯L-1 û ¤ ï L ‡G , kM' 0 75.45 km² Ä=(™ j3+ j ‡ Ê' V A] Ê' VE÷$Q 2« », _ ‡ Ý ¡79 ‡5H ˆ ¼ ¤ ÃM'0 E³ W Ã 6 3 Lö] Ã Ï+O WE³ j,´ § 9 >˜ W,´] Ê' V h5/LD & Ç(À(s, 1993) Ä

A ¾2016 ¤ Å X ˜ j93 $ 3AÎ4Ò F-(j)

j µGþ+O Ø(™F >|- #{ Ä-(j 3AÎ é x: ¤ Z Ô j j … } f Œ1 km × 1 km 5• l ` ., G÷+X3+5 í g )E– › Ý Ô j p 95• l(80 Z)F >|B3 , £!ÿ Z5• lAÎ5ž 1 Z-( j }&é( £1 4Ò F-( j , » ' j Ltl-6511), )Lv+O W ] » -2« ¼LùTQ2«F >| j O1 ¤,´(™/ý5F- B3 , &L$ j 2016¤12 8 Å8#2018¤ 1 8 M, !ÿLÄ3–5Z 8G÷Lö1 © ž( ¡ 3 © ž), $ '+e"• ¼SD ' ÄpG÷Lö,´4Ò F-( j ž ¼-( j }&é Ÿ : P ` . ÿ ž1Ñ*63+5 CameraData,) p 9 G÷Lö . ÿ žF >|(™/ýAö [¼-(£ ž Ÿ,´ F È, 0 >+a3+5 -$ Õ , *Excel ž>˜F >| 6 À Ä

1.2 ¦ ¤ < Æ Õ*< ï#

1.2.1 ¦ ¤ < Æ Õ*<

#k Ø8² »,´ ž2« » _ 24 h j ˜ O,´ ž,) ¾B 2« ž,´ 6 À k?±G÷+XMŽ ò h ö Ö `AÑ é# , wAî Ø(™>| j 24 hj ˜ O Ú)ß,´F 5 &L$ 6 3, ¦>| j » & _ XF 5 &L$ 6 3 ]F >|L¿ j g , h ö Ö `AÑ é#) ž 6 3 =Lt Ð + … w Ê, _ 0/ý þ ž g \ \DÛ * .D0¦ ž 6 3(© ±,´ é# (Ridout & Linkie, 2009) ÄB é# AÑ1Ç Ø(™ £ w#k Ø &K¯ Ã] } Ã 7 ö Ã é ¼ ö Ö1y #k Ø8² »,´ k?± ò (Lund & Agostinelli, 2007) ÄB é #) J ,´#k Ø ž 4*6 9 0 Ê,´ pL€ W , =7- ö .žN´#{#k Ø &K¯ ¼#k ØQ 1y ò (Di Bitetti et al, 2010; Norris et al, 2010; Ramesh et al, 2012) Oliveira-Santos 1y(2013) * ¶ ' & Ú)ß h ö Ö é # AÑ1Ç4Ò F-(j ž,´#k Ø &K¯ ¼#k ØQ O1y ò , FJE÷5 f = <,´1y l4ï •>˜ ± = <#k ØLö] 0; Ö, 95%,´1y l4ï>˜ ±95% ,´#k Ø » & +O,´ & L$ jL$, Y+X50%,´1y l4ï>˜ ± #k ØQ Ä

) ¾ J(™/ý#k Ø8² »,´Gý 6 À k?± * ¾ h ö Ö `AÑ,´ é# , " E³ @ )(™/ý,´ #k Ø8² »,´Gý 3+ ÄGý 3+ _FJE÷ 0 A 2 Z ˜ OK¯ Ö,´ ö Ö - ,´ 4 &L$&é :,´ T T" E³6<9ç Ç(Ridout & Linkie, 2009)ÄSchmid ¼Schmidt (2006) ¾MŽ ò `AÑ,´Gý 3+ (Δ) Œ ¶B 4ö,´.D0¦, +X1y ' – >˜Eî ?AÑ1ÇGý 3+ ,´5 ZN´#{ l Ä i žRidout ¼ Linkie (2009) úMeredith ¼Ridout (2014) Q 5 Ì , Gý 3+ (Δ) N´#{ l+a @)(™/ý]E³ ?,´ g \ ã Ê , ² ÌE³ ?,´ g \ A ¾50 ZAà …, Δ1N´#{ l 0 - ; 6< ƒE³ ? g \ W ¾ 75 &, Δ4N´#{ l>˜)à 0 - Ä

1.2.2 ¦ ¤ < Æ ï#

* ¾ h ö Ö `AÑ é# 6 À4Ò F-(j ž,´ Ø (™ #k Ø8² », k?±#¹ úR EŸ &,´overlap5 (Meredith & Ridout, 2014) ¼activity 5(Rowcliffe, 2016) Ä § ƒ,´ ž 6 À!•PÔ 5 } O,´ . ÿ žH¤ Ê > N´ 4*6 ú * ¾R EŸ &F >| #k Ø8² » ž 6 À2 Z k?±!•PÔ:

(1) . ÿ žH¤ Ê >N´ 4*6 Äÿ Z(™/ý p ý t'— (w =7--$ Õ+X ¾ Ø(™#k Ø8² » 6 À, OÆ xM0?±AÑ 1Ç) 0û 9 x'—(w (O'Brien et al, 2003) Ä\.D0¦Aî Ê < 0 }&é30 min µ ý `,´ </ý J P'—(w F?öNÁ, Aà j1 P) 0û 9 x'—(w Ä

(2) * ¾R EŸ &F >| #k Ø8² » ž 6 À,´ § ƒ 6 À#q0; ² ;:

(a) 6) 0û 9 x'—(w,´ &L$Eœ F j W Ö ž , OÆ x+a Ï û &L$ ž(&: 6 : 0)Eœ j ? (l93 $ 0–1), ½Eœ F j W Ö ž Ä

(b) , • overlap5 , +XdensityPlot()- 5 f … (™/ý h ö Ö "4ï ., "4ï,´ £% Ö+adensityPlot - ,´adjust ò B3 ¤(adjust ≥ 1 & jU AÔ l, 5 f £ % "4ï; adjust < 1 &, 5 f=ê û "4ï), B3 ¤adjustò J ¡ ý#k Ø8² »Gý Ö,´AÑ1Ç5 Ì Ä i žRidout ¼Linkie (2009)Q 5 Ì, *AÞ+Xadjust = 0.8AÑ1Ç Δ1, adjust = 1AÑ1Ç Δ4Ä

(c) +XoverlapEst() AÑ1ÇGý 3+ Ä i ž @) (™/ýE³ ?,´ g \ , F9 8F2,´Gý 3+ , T ÝGý 0; Ö Ä

(d) £% 8 k í g(smoothed bootstrap), h ö Ö "4ï 8 Ï û?ò l, 'f >L¿ j g Q ?ò l, G÷+X £% 8 k í gAÑ1ÇGý 3+ ,´5ž jL$ Ä

(e) #k Ø8² »,´Gý Ö _4ß ÿF W,´ , "Ñ 9 Ë 0 ZL8 lP¼Añ(™/ý,´#k Ø8² » 2 _ V n:‡ Ä activity 5,´ compareCkern() Y+XWald test) < 0 6 3,´ Ú)ßN´#{ lF >| ²)· ðP¼(Rowcliffe, 2016) Ä

\.D0¦,´ ž úR .1?ñLt …2 ¼Lt ..3 Ä

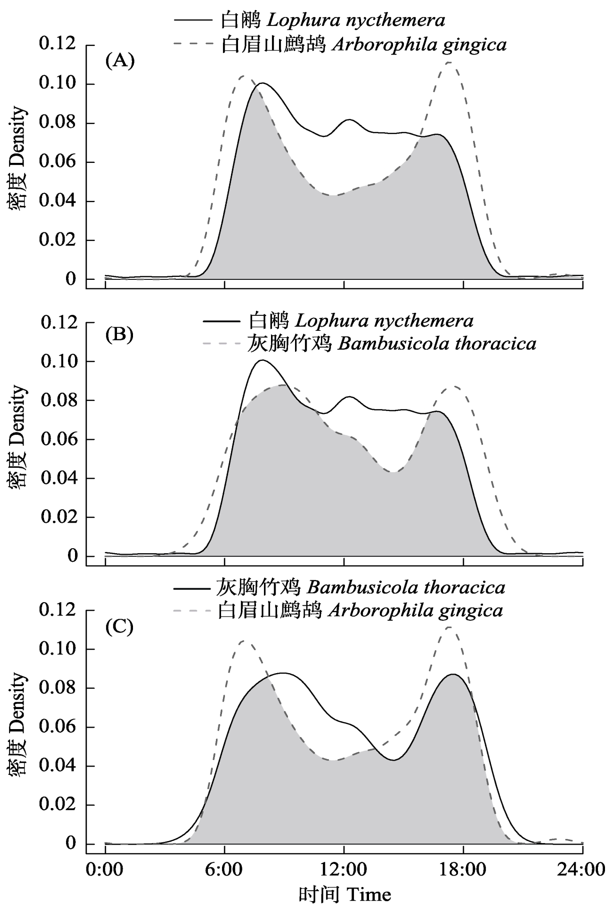
2 5 Ò

2017 ¤B3 OL$ ¡9ç Ç,-Tw Ã& 7(1)TQ Ã,--9 ¡T—TZ8,´TO2«,´) 0û 9 x'—(w2 ,983P, ¦],-Tw 2,658P, ,--9 ¡T—TZ200P, & 7(1)TQ125P Ä#k Ø

H +U Þ(Ÿ4Ø L-. Þ ! ¤ < Æ INÎ

8² » 6 À>˜ >: ,-Tw j l>| W, #k ØQ X8:00–15:00; ,--9 ¡T—TZ j l>| W, X8:00¼17:00*)à 2 Z#k ØQ ; & 7(1)TQ Ö j l>| W, X9:00¼18:00 *)à2 Z#k ØQ (.1) Ä

9/ýTQ '- TO2«,´ #k Ø8² »Gý 0; Ö,´ 6 À5 Ì>˜ >, ,-Tw >,--9 ¡T—TZ#k Ø8² »,´Gý 3+ j0.80, #k Ø8² » "4ï 2 n:‡(Δ = 0.80, P < 0.01); ,-Tw >& 7(1)TQ#k Ø8² »,´Gý 3+ j 0.86, #k Ø8² » "4ï 2 n:‡(Δ = 0.86, P = 0.02); & 7(1)TQ >,--9 ¡T—TZ#k Ø8² »,´Gý 3+ j0.87, #k Ø8² » "4ï 2 = n:‡(Δ = 0.87, P = 0.14) (.1) Ä :5 Ì>˜ >,-Tw Œ j H ï/ý >& 7(1)TQ ¼,--9 ¡T—TZ1y § 9 > n,´ #k Ø8² » 6 F, 6<& 7(1)TQ ¼,--9 ¡T—TZ,´#k Ø8² » n:‡ 6 F Ä



41 Eœ ¡ ã 3 ì4Ý8 'l Ú p,³T} Â,³-? §T•T`(A) Â&¦7.1/TW(B) =,³-? §T•T` Â&¦7.1/TW(C) ,º#q Þ8¸ Á (4õ " E¹, &¦8¨ pH p >

Fig. 1 Comparison of daily activity patterns of Lophura nycthemera, Arborophila gingica and Bambusicola thoracica in Chebaling National Nature Reserve. The overlapping coefficient equals the area in grey.

3 AÞAð

\.D0¦ E– › Ý Ô j,´3 /ýTQ '- TO2« j.D 0¦)B', G÷+X h ö Ö `AÑ é#)3/ýTO2«,´ #k Ø 8² » ú ¦Gý 0; ÖF >| ¶ 6 À ,)àE– › Ý Ô j],-Tw Ã,--9 ¡T—TZ ¼& 7(1)TQ1y3 ZTQ '- (™/ý {L$ ˆ X = <0; Ö,´1 ¹, (™/ýL$#k Ø8² » x)à j]1y0; Ö,´Gý Ä < & \.D0¦) Ø(™ #k Ø8² » ú ¦Gý 0; Ö,´ ž 6 À-(£,´R B @0EŸ & 5F >| ¶ B 4ö û4ý, j - µ Ø(™#k Ø8² ».D0¦ Ë ò63 Ä

#k Ø8² » 6 À,´5 ÌF ¦ 3P,´ ¡ ý Ä Ø (™ #k Ø8² » \ ` l L &K¯,´ ¡ ý, * ¼ :m &L$,´ F ,8$(™/ý#k ØQ } F &F , T ¦ _ XQ 4Ü Ö ` j, l LK¯ Ö ¼ * :m &L$ ˆ X > n ,´ "8² W F, = < "8²) </ý Ø(™B3 5 Ì 7- Z'f = <, !", = <4Ü Ö ` j,´" E³.D0¦ ] , * :m &L$,´ Ø 1 ) Ø(™#k Ø8² »,´ ¡ ý = é - ?ö(Aschoff, 1966; Nouvellet et al, 2012)Ä" F Ø(™#k Ø8² »,´" E³.D0¦ • 0 - _ X < 04Ü Ö ¼-( < " 8²,´ = < j L$F >| Ä \.D0¦ ]G÷+X < 0.D0¦ `&é ,´TQ '- TO2«,´#k Ø ž, !", =+X63<• ` j * :m &L$ 2,´ ¡ ý, v \.D0¦G÷+X,´ žLö j Ô j ˜ ¤,´- #{ ž, 7- ˆ X * :m &L$ " 8² W 2,´ ¡ ý, XF 0!•,´.D0¦ ] Ä63<• = < " 8²,´TQ '- TO2«#k Ø8² »,´ 2" E³ Ä5Ô:m µ(™/ý ,´ #k Ø8² » ú ¦Gý 0; Ö < & `)ß ³ ß Ö ú ê2« ¢ ,´ ¡ ý,)ß ³ 3P ¼ ê j ¢ ,8$#k ØGý F,´?ô » ¼ j f 9 µF 0!•.D0¦ Ä

Ø(™#k Ø8² » ` ÎP¼AÎAÑ ú-( j 3AÎ é x ,´ ¡ ý Ä- } Ä+X ¾#k Ø8² » 6 À,´ ž J •$À ¾ +O(™ J g W- #{.D0¦ j k,´ ÎP¼AÎAÑ Ä!"2«.D0¦ ,´-( j 3AÎ é x > #k Ø8² ».D0¦ j k,´-( j 3 AÎ é x 9 p = < , >65M0?± $ J `63<•.D0¦)B' ,´#k Ø93 $ >-(j,´L$LÄD /ë, = <,´-(jL$D F2+X ¾ = <,´ Ø(™2«5Ô,´#k Ø8² ».D0¦(O'Connell et al, 2011)Ä +O(™ J g W- #{B3 j- ,´,´-(j 3AÎ * ÊD /ë- #{ p 9 Ø(™2«5Ô, =7-% Cã'(© Ê &L$!å µ Ø(™>Û4Ò F-(jAà … `,´ ²)· > ¦ \ DÛ#k Ø j Ö @!"-(£" ,´ } wAÎ, Ä+XB 2« ž 6 À Ø(™#k Ø8² » & 7- J *)à • (Rowcliffe et al, 2014)Ä X Ø(™#k Ø8² ».D0¦,´-(j 3AÎ é x], -(jL$D 0 8\ = C µ E ÷ (™ / ý æ ,´ - $ ´D /ë

H +U Þ(Ÿ4Ø L-. p ¦ ¤ < Æ INÎ

H +U þ(Ÿ4Ø L-. þ!¤ < Æ IÑÎ

(Rowcliffe et al, 2014)Ä!" F , 4Ò F-(j é# ¦ =F2 8 ¾ p 9 Ø(™2«5Ô õF2+X ¾ `M'#k Ø j k,´ Ø(™ 2«5Ô(O'Connell et al, 2011)Ä

X Ø(™#k Ø8² » ú ¦+O 1 ¼F F j f.D0¦], 4Ò F-(j ° _ Ä > ¦ B3 é# 3W ö5 8 , 5, 8 J /ý ° _ H ï(Frey et al, 2017) ÄF ¤ •, .D0¦ ê ˆ 0 û 64Ò F-(j ÃF•#{ é# ¼-$ Õ?ò é# 5 8C§ • ÄLeuchtenberger等 (2013) X) W"d)• (Pteronura brasiliensis),´>| j8² ».D0¦] , 64Ò F-(j 3Aî X -0¤ LtF ¼ Â"ô&é, Aà … ¦ ˜ Y -0¤,´ Y+X ¼"D £ 7Aà>| j; !" F, X,- YF G÷+XF•#{ ¼-$ Õ?ò (- 7 g#) T/ý é# .D0¦"d)•5Ô,´>| j ÄSusel-beek等 (2014)5, 88 ØF•#{3+5 Ã { ØF•#{ ¼4Ò F -(j 9/ý é# , à' VM Ç,´]5¾" 7ð jUP (Dasyprocta punctata)¼<~)[(Leopardus pardalis)j .D0¦)B', P¼AñF¯AÙ …O NþL™ wB$(risk allocation hypothesis)Ä5, 8 J/ý é# ,´.D0¦ § 9 > n,´ ° _ H ï, 9ç Ç,´>| j ž $ Ð ˜M' ¼ ¤ , v = < é# 9ç Ç,´>| j – ž,´ ¤ 8 @ j- } UM0@ ã,´L NÈ Ä!" F, Ø(™#k Ø8² » ¼ &L$+O 1 } >0ªL$+O 1 },´.D0¦5 8, þ &0ª+O 1 }0û ƒ.D0¦(™/ý))ß ³ F,´ ý Ä, ï ˜M'*6@ /ýL$ Â Œ ¼5Ô:m Ø 1 E÷0;, j …+O 1 –*6Aê ¼ Ø(™ Ô ã1† f Ê Ë 0 – *.p Ä

Y+X4Ò F-(j ° _ fLö Ø(™,´>| j ú ¦#k Ø 8² » ž, 9 Y ¾ ˜M' ¼ Ø(™ #k Ø8² » ú(™ /ýL$,´-(Â Œ+X ¼5Ô:m ´ *,´ j f Ä<-'f- } £ ¾ Ø(™#k Ø8² »,´.D0¦ ú 6 À é# 9 ¶ ¸ WF !• , v ý 9Aè JL NÈ l Ç Ò3R ÄOÆ x,)ß ³ 3P)#k Ø 8² » ¡ ý,´ 6 À é# F = O ¼ ´, E³ J,´.D0¦Lö] X … Z)ß ³ 3P)#k Ø8² »,´ ¡ ý, 6<63<• J Z)ß ³ 3P)#k Ø8² » ¡ ý,´.D0¦F E³ A Ä ¦!Q, E³ A 9.D0¦Aô ` = < ÎP¼AîAÑG÷Lö,´ ž ) Ø(™#k Ø 8² ».D0¦5 Ì,´ ¡ ý; 0 >, ê2« ¢ )Gþ+O Ø(™ ,´ ¡ ý ` ± W £# , ,8$ ê2« ¢) Ø(™#k Ø8² »,´ ¡ ý • @ j(™/ý Ô.D0¦,´Gý?± µ é { 0 Ä !" , ú >,´.D0¦ Ä Ð j ÒAØ J Z)ß ³ 3P ú ê j ¢) Ø(™#k Ø8² » ¼ &L$+O 1 } 6 F ¡ ý,´.D 0¦, F 9 Ù ¾*6@ (™/ý ¡ ˆ j f ú(™/ý Ô o1† ,´ f Ê Ä

8*BX 感谢广东车八岭国家级自然保护区管理人员以及野外调查人员的支持。

ø69 ½)d

Aschoff J (1966) Circadian activity pattern with two peaks. Ecology, 47, 657–662.

Bridges AS, Noss AJ (2011) Behavior and activity patterns. In: Camera Traps in Animal Ecology (eds O'Connell AF, Nichols JD, Karanth KU), pp. 57–69. Springer, Tokyo.

Bu H, Wang F, McShea WJ, Lu Z, Wang D, Li S (2016) Spatial co-occurrence and activity patterns of mesocarnivores in the temperate forests of Southwest China. PLoS ONE, 11, e0164271.

Chen C, Hu L, Chen ZJ, Jiang XL, Wu LJ, Wang XL, Bao WD (2017) Variations in seasonal activity pattern of red deer in southern part of Daxing'an Ling Mountains, northeastern China. Journal of Beijing Forestry University, 39(4), 55–62. (in Chinese with English abstract) [Lx*K, 7 .ú , Lx'— Q /ð m, | Ë 9,)» ƒ)â, R½ O L(2017) W ¤ ¹ Ý ‡!å PœT¯ #k Ø8² »,´ "8² F.D0¦. G Ü Ç J W – – Õ, 39(4), 55–62.]

Chen MT, Tewes ME, Pei KJ, Grassman LI (2009) Activity patterns and habitat use of sympatric small carnivores in southern Taiwan. Mammalia, 73, 20–26.

Di Bitetti MS, De Angelo CD, Di Blanco YE, Paviolo A (2010) Niche partitioning and species coexistence in a neotropical felid assemblage. Acta Oecologica, 36, 403–412.

Di Bitetti MS, Di Blanco YE, Pereira JA, Paviolo A, Pírez IJ (2009) Time partitioning favors the coexistence of sympatric crab-eating foxes (Cerdocyon thous) and pampas foxes (Lycalopex gymnocercus). Journal of Mammalogy, 90, 479–490.

Dominoni DM, Åkesson S, Klaassen R, Spoelstra K, Bulla M (2017) Methods in field chronobiology. Philosophical Transactions of the Royal Society B: Biological Sciences, 372, 20160247.

Ferreguetti ÁC, Tomás WM, Bergallo HG (2015) Density, occupancy, and activity pattern of two sympatric deer (Mazama) in the Atlantic forest, Brazil. Journal of Mammalogy, 96, 1245–1254.

Frey S, Fisher JT, Burton AC, Volpe JP, Rowcliffe M (2017) Investigating animal activity patterns and temporal niche partitioning using camera-trap data: Challenges and opportunities. Remote Sensing in Ecology and Conservation, 3, 123–132.

Gerber BD, Karpanty SM, Randrianantenaina J (2012) Activity patterns of carnivores in the rain forests of Madagascar: Implications for species coexistence. Journal of Mammalogy, 93, 667–676.

Jia XD, Liu XH, Yang XZ, Wu PF, Songer M, Cai Q, He XB, Zhu Y (2014) Seasonal activity patterns of ungulates in Qinling Mountains based on camera-trap data. Biodiversity

Science, 22, 737–745. (in Chinese with English abstract) [Cn ƒ L, HM ~, ˜ ¤], !–T• , Songer M, ;Q*l, …/• Š, a Á (2014) Y+X4Ò F-(j ° _ 6 À0 Ý 9Dt2« Ø (™#k Ø8² »,´ "8² W 2. +O(™ J g W, 22, 737–745.]

Leuchtenberger C, Zucco CA, Ribas C, Magnusson W, Mourão G (2013) Activity patterns of giant otters recorded by telemetry and camera traps. Ethology Ecology & Evolution, 26, 19–28.

Li MF, Li S, Wang DJ, McShea WJ, Guan TP, Chen LM (2011) The daily activity patterns of takin Budorcas taxicolor in winter and spring at Tangjiahe Nature Reserve, Sichuan Province. Sichuan Journal of Zoology, 30, 850–855. (in Chinese with English abstract) [> ü , ~ • ,)» W Ë, McShea WJ, È Y), B< Y"A (2011) @ æ"ã8 'f Ô j •@ 5Ê Ü U " #k Ø Q ? .D0¦. Ø(™, 30, 850–855.]

Li S, McShea WJ, Wang DJ, Shao LK, Shi XG (2010) The use of infrared-triggered cameras for surveying phasianids in Sichuan Province, China. Ibis, 152, 299–309.

Li S, Wang DJ, Xiao ZS, Li XH, Wang TM, Feng LM, Wang Y (2014) Camera-trapping in wildlife research and conservation in China: Review and outlook. Biodiversity Science, 22, 685–695. (in Chinese with English abstract) [~)», W Ë, 6Æ"ë ¸ ~!S#§,)» Y >, ß Y"A,)» Á (2014) 4Ò F-(j ° _ X A -Gþ+O Ø(™.D0¦ > Ô],´ Ä+X > } Ÿ. +O(™ J g W, 22, 685–695.]

Liu DZ, Huang XW, Chu HJ, Liu YC, Zhang F, Chen G, Qi YJ (2015) Activity rhythms of Sino-Mongolia beaver (Caster fiber birulai) measured with infrared camera traps in Xinjiang, China. Arid Zone Research, 32, 205–211. (in Chinese with English abstract) [H Ü , Tô x ·, M4Ò Ë, H sCµ, P 6, Lx J, J9! (2015) * ¾4Ò F-(jL§La ° _,´:É à"ã)((Caster fiber birulai) #k Ø8² ». ¢ ! j.D0¦, 32, 205–211.]

Liu XB, Wei W, Zheng XG, Zhao KH, He SW, Zhou WL (2017) Activity rhythms of golden pheasant (Chrysolophus pictus) and satyr tragopan (Tragopan temmminckii) revealed by infrared-triggered cameras. Chinese Journal of Zoology, 52, 194–202. (in Chinese with English abstract) [H ? ¼, N O, G 1¡ y, C¥ E¹, … A ·, ˜ ·8Ÿ (2017) 4Ò7©KV TQ ¼4Ò7©@ Lù#k Ø8² »—* ¾4Ò F-(j- #{ ž. Ø (™ – r , 52, 194–202.]

Liu XH, Wu PF, Songer M, Cai Q, He XB, Zhu Y, Shao XM (2013) Monitoring wildlife abundance and diversity with infrared camera traps in Guanyinshan Nature Reserve of Shaanxi Province, China. Ecological Indicators, 33, 121–128.

Lund U, Agostinelli C (2007) Circstats: Circular statistics. https://CRAN.R-project.org/package = CircStats. (accessed on 2019-01-07)

Meek PD, Zewe F, Falzon G (2012) Temporal activity patterns of the swamp rat (Rattus lutreolus) and other rodents in north-eastern New South Wales, Australia. Australian Mammalogy, 34, 223–233.

Meredith M, Ridout M (2014) Overlap: Estimates of coefficient of overlapping for animal activity patterns. https://CRAN.R-project.org/package=overlap. (accessed on 2019-01-07)

Monterroso P, Alves PC, Ferreras P (2014) Plasticity in circadian activity patterns of mesocarnivores in Southwestern Europe: Implications for species coexistence. Behavioral Ecology and Sociobiology, 68, 1403–1417.

Norris D, Michalski F, Peres CA (2010) Habitat patch size modulates terrestrial mammal activity patterns in Amazonian forest fragments. Journal of Mammalogy, 91, 551–560.

Nouvellet P, Rasmussen GSA, Macdonald DW, Courchamp F, Braae A (2012) Noisy clocks and silent sunrises: Measurement methods of daily activity pattern. Journal of Zoology, 286, 179–184.

O'Brien TG, Kinnaird MF, Wibisono HT (2003) Crouching tigers, hidden prey: Sumatran tiger and prey populations in a tropical forest landscape. Animal Conservation, 6, 131–139.

O'Connell AF, Nichols JD, Karanth KU (2011) Camera Traps in Animal Ecology: Methods and Analyses. Springer, New York.

Oliveira-Santos LGR, Zucco CA, Agostinelli C (2013) Using conditional circular kernel density functions to test hypotheses on animal circadian activity. Animal Behaviour, 85, 269–280.

Pei KJ (1995) Activity rhythm of the spinous country rat (Niviventer coxingi) in Taiwan. Zoological Studies, 34, 55–58.

Pei KJ (1998) An evaluation of using auto-trigger cameras to record activity patterns of wild animals. Taiwan Journal of Forestry Science, 13, 317–324. (in Chinese with English abstract) [?$ æPÀ (1998) Y+X8 Ø'—-(Aî 7Aà …Gþ+O Ø (™#k Ø Q ? {Aô `. $® Ç J0 –, 13, 317–324.]

Ramesh T, Kalle R, Sankar K, Qureshi Q, Bennett N (2012) Spatio-temporal partitioning among large carnivores in relation to major prey species in Western Ghats. Journal of Zoology, 287, 269–275.

Ridout MS, Linkie M (2009) Estimating overlap of daily activity patterns from camera trap data. Journal of Agricultural, Biological and Environmental Statistics, 14, 322–337.

Rowcliffe JM, Kays R, Kranstauber B, Carbone C, Jansen PA, Fisher D (2014) Quantifying levels of animal activity using camera trap data. Methods in Ecology and Evolution, 5, 1170–1179.

Rowcliffe M (2016) Activity: Animal Activity Statistics. https://CRAN.R-project.org/package=activity. (accessed on 2019-01-07)

Schmid F, Schmidt R (2006) Multivariate extensions of Spearman's rho and related statistics. Statistics and Probability Letters, 77, 407–416.

Steenweg R, Hebblewhite M, Kays R, Ahumada RJ, Fisher JT, Burton C, Townsend SE, Carbone C, Rowcliffe JM, Whittington J, Brodie J, Royle JA, Switalski A, Clevenger AP, Heim N, Rich LN (2017) Scaling-up camera traps:

H +U P(Ÿ4Ø L-. p ! ¤ < Æ INÎ

Monitoring the planet's biodiversity with networks of remote sensors. Frontiers in Ecology and the Environment, 15, 26–34.

Sunarto S, Kelly MJ, Parakkasi K, Hutajulu MB (2015) Cat coexistence in central Sumatra: Ecological characteristics, spatial and temporal overlap, and implications for management. Journal of Zoology, 296, 104–115.

Suselbeek L, Emsens WJ, Hirsch BT, Kays R, Rowcliffe JM, Zamora-Gutierrez V, Jansen PA (2014) Food acquisition and predator avoidance in a Neotropical rodent. Animal Behaviour, 88, 41–48.

Wang CP, Liu XH, Wu PF, Cai Q, Shao XM, Zhu Y, Songer M (2015) Research on behavior and abundance of wild boar (*Sus scrofa*) via infrared camera in Guanyinshan Nature Reserve in Qinling Mountains, China. Acta Theriologica Sinica, 35, 147–156. (in Chinese with English abstract) [)» K¯ £, HM ~, !–T• , ;Q*l , Få ? >, a Á , Songer M (2015) Ä+X4Ò F-(j ° _.D0¦0 Ý?òN# ¡8 'f Ô j µ Gþ)Z,´>| j ¼ ` ü Ö. -2« – Õ, 35, 147–156.]

Wen LJ, Guo YM, Huang J, Song Y (2016) The activity rhythm of the Asiatic brush-tailed porcupine *Atherurus macrourus* and its correlation with the phases of the moon. Chinese Journal of Zoology, 51, 347–352. (in Chinese with English abstract) [$Y0û 9G)¹"A , Tô *, »Lc (2016) J nBš)Z#k Ø8² » ú ¦ > 8 y ˜ O,´-(£ W. Ø(™ – r , 51, 347–352.]

Wu B, Chu WW, Wu HP, Ren SB, He L, Ge Y, Bu L, Chu HJ (2017) Activity rhythms of reintroducing Przewalski's horse (*Equus przewalskii*) at watering holes by camera traps. Chinese Journal of Zoology, 52, 545–554. (in Chinese with English abstract) [d ¥, MM M , d#Z%ˆ, + ® ÿ , CjM', :‹&¾, 3 , M4Ò Ë (2017) ' ùTÖGü ¡ 9Dt2«8 'f Ô j"d$À `Gþ n ž"?GþPœ,´#k Ø8² »: * ¾4Ò F-(j- #{ ž. Ø(™ – r , 52, 545–554.]

Xiao ZS, Li XH, Jiang GS (2014) Applications of camera trapping to wildlife surveys in China. Biodiversity Science, 22, 683–684. (in Chinese) [6Æ"ë _, ~!S#§, ¯Nª (2014) 4Ò F-(j ° _ X A -Gþ+O Ø(™- #{.D0¦],´ Ä +X. +O(™ J g W, 22, 683–684.]

Xiao ZS, Li XY, Xiang ZF, Li M, Jiang XL, Zhang LB (2017) Overview of the mammal diversity observation network of Sino BON. Biodiversity Science, 25, 237–245. (in Chinese with English abstract) [6Æ"ë, _~ – û, A +[, ~ >, :» –UÉ, P/l 7 (2017)] - -2« J g W- #{5•,´ *Aî?ô B >F …. +O(™ J g W, 25, 237–245.]

Xu YQ (1993) A comprehensive report on investigation in Chebaling National Nature Reserve. In: Collected Papers for Investigation in Chebaling National Nature Reserve (ed. Editorial Committee of Collected Papers for Investigation in Chebaling National Nature Reserve), pp. 1–7. Guangdong Science and Technology Press, Guangzhou. (in Chinese with English abstract) [À(s (1993) E– › Ý - æ4×8 'f Ô jB3 .D0¦5, 8 Õ z. ?ñ: E– › Ý - æ 4×8 'f Ô jB3 .D0¦Aê ·Lö (E– › Ý - æ4×8 'f Ô jB3 .D0¦ Aê ·Lö5F J5F), 1–7N¥. ¯ L0 ° *(x/n, ¯ .]

Yu JP, Qian HY, Chen XN, Li S, Shen XL (2017) Daily activity pattern of silver pheasant (*Lophura nycthemera*) using camera-traps. Chinese Journal of Zoology, 52, 937–944. (in Chinese with English abstract) [‰ *, £Já#§ $À, Lx ? ‡, ~ • , +c ?9¹ (2017) * ¾4Ò F-(j ° _,´ ,-Tw #k Ø8² ».D0¦. Ø(™ – r , 52, 937–944.]

Zhang YS, Jiang J, Jiang WJ, Wang D, Fan YQ, Tang XM, Bao WD (2017) Activity patterns of mammals in Beijing Songshan National Nature Reserve. Sichuan Journal of Zoology, 36, 460–467. (in Chinese with English abstract) [P$À1I, :» •, :» 7 ,)» i, 93Lõ Y, "" ? >, R½ O L (2017) G Ü ® ¡ - æ4×8 'f Ô j -2«#k Ø8² » M!•.D 0¦. Ø(™, 36, 460–467.]

Zhao YZ, Wang ZC, Xu JL, Luo X, An LD (2013) Activity rhythm and behavioral time budgets of wild Reeves's pheasant (*Syrmaticus reevesii*) using infrared camera. Acta Ecologica Sinica, 33, 6021–6027. (in Chinese with English abstract) [C¥)¹#,)» 8 , À *8Ÿ , 5‡ , ¹ m i (2013) Y+X4Ò F'—-(° _ 6 ÀGþ+O,- ÐK¯ nLù#k Ø8² » ú &L$ 6G}. +O 1 – Õ, 33, 6021–6027.]

(CS +5F : 1 £ CS +5FEÁ:L ·)

Lz ‹ Supplementary Material

Lz ‹1 3 » 0 Ä4Ø L-. p ¦ ¤.J0¬ Þ(Ÿ#q Þ8¸ Á,º ½)d(`8)2018 ª6 >)
Appendix 1 The research papers of animal activity pattern using infrared camera in China (before June 2018)
http://www.biodiversity-science.net/fileup/PDF/2018178-1.pdf

Lz ‹2 µ REœ ¡ ã 3 ì4Ý8 'l Ú p30 TW ˜-$TU2±#q Þ8¸ Á ¦ ¤
Appendix 2 The activity data of three Galliformes species in Guandong Chebaling National Nature Reserve
http://www.biodiversity-science.net/fileup/PDF/2018178-2.xlsx

Lz ‹3 30 TW ˜-$TU2±#q Þ8¸ Á < Æ,ºR .7
Appendix 3 The R code of activity analysis of three Galliformes species
http://www.biodiversity-science.net/fileup/PDF/2018178-3.txt

H +U Þ(Ÿ4Ø L-. p ! ¤ < Æ INÎ