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洞庭湖区社鼠的繁殖生态

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摘要:在洞庭湖区域,社鼠(*Niviventer confucianus*)种群主要栖息在山区和丘陵地带的林地内。总体而言,其种群雌性比基本维持在50%左右,但在季节间和年龄组间有一定的差别,雌性比在冬、春季较低,夏、秋季的雌性比都超过50%。年龄组间,雌性比最高的为幼年组66.7%,亚成年和成年组的雌性比接近50%,而老年组的雌性比为最低,为33.3%。所有雌鼠全年的怀孕率为31.1%,平均胎仔数为3.7只,繁殖指数为0.58。春、夏季怀孕率较高,冬季没有捕获到怀孕的雌鼠,仅捕获到有怀孕经历(有宫斑)的雌鼠。繁殖指数在夏、秋季维持高峰水平。雌性社鼠总的参产率为53.3%,各季间呈现从春、夏到秋逐渐增加的趋势,冬季停止怀孕。可见夏、秋季为雌鼠的繁殖高峰期。随着年龄组增长,平均胎仔数有明显增加的趋势,老年组胎仔数最高,而繁殖指数以成年组最高,说明成年组是种群中繁殖的主体。雄性社鼠的睾丸下位率全年总计为75.6%,分四季平均为86.0%,夏、秋季维持在较高水平,冬、春季稍低,低谷在春季。下位睾丸的重量与大小有明显的季节变化,呈现春、夏、秋、冬逐渐下降的规律,春季与冬季相比,有显著性差异,说明开春后,雄性社鼠在生殖潜能上已有明显变化。这些特征与雌鼠的繁殖高峰基本吻合。说明社鼠主要在春、夏、秋季繁殖,繁殖盛期在夏秋季。从不同年龄组看,幼年组个体不参与繁殖,亚成年组个体开始参与繁殖,繁殖主体是成年组个体。

关键词:社鼠;繁殖生态;洞庭湖区

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Reproductive ecology of sulphur bellied rat (*Niviventer confucianus*) populations in the Dongting Lake region

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Abstract: Sulphur bellied rats (*Niviventer confucianus*) were collected from Taoyuan County in 1998 to 2001, from YueYan County in 1992 to 1994, and in 2003 to 2004. The animals were caught primarily in their preferred woodland habitat. A total of 109 specimens were captured, and 90 animals were autopsied to determine reproductive condition. Position, size and weight of testes were noted in males. For females, the reproductive tract was examined for tubal condition of the uterus, number and size of embryos, and placental scars. Specimens were assigned to four age classes based on body mass: juvenile (body weight ≤ 35.0g), sub-adult (body weight from 35.1 ~ 50.0g), adult (body weight from 50.1 ~ 80.0g), and old-adult (body weight > 80.0g). Males with testes had dropped into the scrota, and females for which the uterus was tubal were considered sexually mature.

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Females with embryos or visible uterine scars were considered as reproductive animals.

The total sex ratio (M/F) is approximately 1:1, but it varies in different seasons and with different age class. The proportion of females is higher than that of males except during spring and winter, and is higher in juvenile (66.7%) and but lower in old-adults (33.3%). The total percentage of pregnancy in captured females was 31.1%, which also varied with season and age classes. Rates of pregnancy in spring, summer and autumn were 38.1%, 37.5% and 30.0%, respectively, with no breeding in winter. Juveniles were immature with no reproductive activity, but the sub-adult group (20.0%) had begun to reproduce. Proportion of pregnanacy was highest for the adult group (40.0%), and dropped (33.3%) in the old-adult group. The average number of embryos in a litter was 3.7 ± 1.3 (Mean ± SD), and ranged from 2 to 8. Litter size varied with changes in the seasons, being lowest in spring (3.0 ± 0.8), highest in autumn (5.0 ± 1.0), and intermediate in summer (4.3 ± 1.5). The litter size of the animals increased with age class ($r = 0.680$, $df = 13$, $p = 0.015$), and also showed a significant positive correlation with body weight ($r = 0.631$, $df = 13$, $p = 0.021$). The old-adult group had the highest litter size (6.0), which might be a common phenomenon in rodents generally.

The index of reproduction for all females was either 0.58 (as total litter size/all animals) or 1.15 (as total litter size/females). Among seasons, the reproductive indices in summer (0.86 or 1.61, respectively) and autumn (0.88 or 1.50, respectively) were higher than those in spring (0.53 or 1.14, respectively) and winter (with no pregnant females). The reproductive index of the adult group was the highest (0.74), followed by the old group (0.67) and sub-adult (0.26). The main group to reproduce was the adult class.

For males, the rate of testes in scrota for all males was 75.6%. Almost all captured males had scrotal testes in summer and autumn, whereas the rates of scrotal testes in spring (58.3%) and winter (85.7%) were lower. Among age classes, the rates of scrotal testes increased gradually from 0.0% in juveniles to 100.0% of old-adults. The size and weight of testes of mature males changed significantly among seasons (weight: ANOVA, $F_{3,33} = 11.458$, $p < 0.001$; long diameter of testes: $F_{3,33} = 3.479$, $p < 0.05$; short diameter of testis: $F_{3,33} = 4.145$, $p < 0.05$). Size and weight of testes in winter were always lowest. From juveniles to old-adults, the weight, long diameter, and short diameter of testes increased gradually. There were statistically significant differences among age classes (weight: ANOVA, $F_{3,44} = 13.291$, $p < 0.001$; long diameter of testis: $F_{3,44} = 19.458$, $p < 0.001$; short diameter of testis: $F_{3,44} = 16.965$, $p < 0.001$).

Reproductive traits of males were similar to those of females by season and age classes, so it can be concluded that the rat breeds during the spring to autumn, and stops breeding in winter. The most favorable breeding season of the animals is summer and autumn, and the adult group is the main reproductive class. The reproductive potential peaks in summer and autumn, when the index of reproduction, percentage of pregnancy, and percentage reproductive females reach a crest, and when the rate of scrotal testes in males is 100%.

Key words: sulphur bellied rat (*Niviventer confucianus*); reproductive ecology; Dongting Lake region

社鼠(*Niviventer confucianus*)为东洋界常见种类之一,属东南亚热带-亚热带型,分布区伸至季风区温暖带[1],在我国大部分地区均有分布[2]。主要栖息在山区和丘陵地带的林地,因此对维护森林生态系统的平衡有一定益处,如社鼠有利于一些植物种子的扩散与萌发、植被的演替等[3~7]。另一方面,社鼠对农、林业生产形成一定的危害,如人工造林区域,在育苗阶段会造成一定经济损失[8];在树种单一的林区也会对果实构成威胁[9];对农业生产的危害仅局限于山边的农田。值得注意的是在鼠传疾病方面,社鼠是山区主要的疫源动物,如在大别山的岳西县境内的调查发现,社鼠为肾综合征出血热主要宿主动物[10]。因此不论从发挥其生态功能,还是控制其危害来讲,均有必要对其野外种群的生物生态特性进行研究,掌握其发生发展规律。目前虽然对其已有一些研究,如汪松等[2]、张子郁等[11]、邓先余等[12]对社鼠的分类地位和亚种的分化等进行过研究;鲍毅新等[13]、张洁[14]分别对浙江和北京地区的社鼠种群进行年龄分组,并对年龄结构进行分析;鲍毅新等[15]和杜卫国等[16~18]报道了浙江一些地区社鼠内脏器官形态学指标;另外在社鼠的生理学[15,19~23]及其种群生态

学[14,24~29]等方面也有较多研究。但与其它常见鼠种相比,对该鼠种群的研究还是相对较少,尤其在洞庭湖区,还未见有较详尽的报道。本文根据在该地区调查积累的相关数据,进行归纳总结,揭示本地区社鼠的繁殖生态学特性。

1 研究地点与方法

洞庭湖区位于长江中游荆江南岸,湖南省北部,东经 111°40′ ~ 113°10′,北纬 28°30′ ~ 30°20′,属中亚热带向北亚热带的过渡区,年平均气温 16.4 ~ 17.0℃,年平均降雨量 1200 ~ 1550mm。1998 至 2001 年在洞庭平原环湖岗地低丘区的桃源、1992 至 1994 年和 2003 至 2004 年在滨湖区的岳阳县进行调查取样,每季调查一次。调查生境主要分为 5 种,丘陵和山区的林地、山边农田、成片农田及农房。调查均采用夹日法,以生葵花籽为饵,用大号铁板夹,当天下午(山林)和晚上(农田)置夹,次天早上和上午收回,夹间距一般在 5m 左右,每种生境的置夹数一般在 300 个以上。农田沿田埂或地边置夹;林地每次调查 4 个不同的山头,丘陵区林地的置夹位置与山边农田的最近距离保持 100m 以上,山区的林地样方在山林深处,离农田较远,林内沿小路或临时踩出一条线路置夹。所捕获的鼠分种类统计。对洞庭湖区的桃源与岳阳采集的社鼠样本称重、测量,然后解剖,仔细观察繁殖情况,记录睾丸是否下降阴囊,测定睾丸的长和宽。记录雌鼠宫角发育状况,怀孕情况:胎仔数、大小及胚胎斑数,最后称取胴体重。

2 结果

1992 ~ 2004 年在桃源和岳阳的系统调查中共捕获的 109 只社鼠。由表 1 可见,社鼠主要在山区和丘陵的林地及山脚农田栖息。很难深入到住宅和平原地区的农田,即使在山区和丘陵的大片农田区域也未捕获到。所捕获的社鼠中,有解剖纪录的 91 只,其中能辨别性别的 90 只,雌雄正好各 45 只,其中桃源种群的雌性比为 1.06(F/M),岳阳种群的雌雄比为 0.92,说明其种群性比基本维持在 1:1。

表 1 社鼠在洞庭湖区不同生境的捕获情况

Table 1 The census data of *Niviventer confucianus* in some habitats of Dongting Lake area

地点 Census area	调查时间 Census time	自然区域 Natural area	生境 Habitat	夹日数 Snaptraps	社鼠捕获率 Rate of capture (%)*	占捕获鼠的比例 Rate in capture mouse (%)
桃源 Taoyuan	1998.3 ~ 2001.12	平原区 Plain area	农田 Farmland	10273	0.00	0.00
		丘岗区 Hilly area	农房 Building	199	0.00	0.00
			大片农田 Farmland	1515	0.00	0.00
			山脚农田 Farmland beside woodland	1283	0.47 (6)	50.00
			林地 Woodland	1233	2.11 (26)	74.29
		山区 Moutainous area	大片农田 Farmland	1224	0.00	0.00
			山脚农田 Farmland beside woodland	1223	0.33 (4)	19.05
			林地 Woodland	1682	1.49(25)	65.79
岳阳 Yueyan	1991.12 ~ 1995.6	平原区 Plain area	农房 Building	2347	0.00	0.00
			农田 Farmland	16122	0.00	0.00
		丘陵区 Hilly area	林地 Woodland	2647	0.34 (9)	2.49
	2000.9 ~ 2004.12	平原区 Plain area	农田 Farmland	3854	0.00	0.00
		丘陵区 Hilly area	林地 Woodland	3648	1.07 (39)	35.45

* 括号内的数值为捕获鼠数 The numbers in parentheses were animals captured

2.1 雌鼠繁殖特征

雌鼠的繁殖特征见表 2,表中的"参产鼠"是指有胎的孕鼠和可见宫斑的经产鼠(有宫斑的孕鼠不重复计算),即已参加繁殖的鼠。雌性社鼠总的参产率为 53.3%,全年的怀孕率为 31.1%,胎仔数较低,平均仅为 3.7 只,繁殖指数为 0.58。胎仔数最低为 2 只,最高为 6 只,出现频率同为 14.3%,出现频率最高的胎仔数为 3 只(35.7%),其次为 4 只(28.65%)。从宫角的宫斑数看,波动范围在 3 ~ 8 之间,据此可以判断,洞庭湖区社鼠的胎仔数应在 2 ~ 8 之间。捕获既有宫斑又怀有胎仔的雌鼠 1 只,于 2004 年 9 月在岳阳的林地内捕获(6 个胚胎 + 7 个宫斑),属于老年组个体。另在桃源,于 1998 年 6 月曾捕获 1 只既有宫斑又怀有胎仔的雌鼠(3 个胚胎 + 3 个宫斑),其体重为 65g,体长 137mm,属于成年组,因此当年的夏秋季,此鼠还有参与 1 ~ 2 次繁殖的机会。

由此可以推论,洞庭湖区的社鼠一年有繁殖3~4胎的可能。就个体来看,宫角已发育为管状的最低体重个体为37g(胴体重27g),有怀孕记录的雌鼠最低体重个体46g(胴体重为30g)。

表2　雌性社鼠(洞庭湖区)各季节的繁殖特征

Table 2　The reproductive characteristics of female *Niviventer confucianus* in each season in Dongting Lake area

季节 Season (月份 Month)	雌鼠数 No. of female	雌性比 Female ratio (%)	参产鼠数① No. of reproductive	参产率② Rate of reproductive (%)	孕鼠数 No of pregnancy	雌鼠怀孕率 Rate of pregnancy (%)	平均胎仔数 Mean litter Size(Mean ± SD)	繁殖指数③ Index of reproduction ($I_{♀}$)
春季 Spring(3~5)	21	46.7	10	47.6	8	38.1	3.0±0.8(2~4)	0.53 (1.14)
夏季 Summer(6~8)	8	53.3	5	62.5	3	37.5	4.3±1.5(3~6)	0.86 (1.61)
秋季 Autumn(9~11)	10	58.8	7	70.0	3	30.0	5.0±1.0(4~6)	0.88 (1.50)
冬季 Winter(12~2)	6	46.2	2	33.3	0	0.0	0.0	0.0
合计 Total	45	50.0	24	53.3	14	31.1	3.7±1.3(2~6)	0.58 (1.15)

①参产鼠=怀孕鼠(只)+有宫斑但未怀孕鼠(只) Reproductive animals = Pregnancy animals + the non-pregnancy animals with placental scar; ②参产率=参产鼠(只)/雌鼠总数(只)(×100% Rate of reproductive = Reproductive animals/the females(×100%;③繁殖指数=胎仔总数/总鼠数;括号内的繁殖指数 $I_{♀}$ 是以雌鼠计算的,表4与表7同 Index of reproduction = Total litter size/all animals; The $I_{♀}$ which were showed in parentheses were calculated on female animals, same as in table 4 and 7

2.1.1　雌鼠繁殖的季节变化　由于样本数较少,计算各项繁殖特征仅以每季为一单位。从表2看,雌性比以冬、春季较低,夏、秋季的雌性比都超过50%。春、夏、秋季怀孕率较高,冬季没有捕获到怀孕的雌鼠,仅捕获到有怀孕经历(有宫斑)的雌鼠。参产率从春、夏到秋逐渐增加,由于冬季雌鼠已停止怀孕,参产率迅速降低。繁殖指数在夏、秋季维持高峰水平,冬季停止繁殖。可见夏、秋季为雌鼠的繁殖高峰期。

2.1.2　不同年龄组雌鼠的繁殖特征　根据捕获群体的发育与繁殖状况,年龄分组可参照鲍毅新等[13]对浙江天目山(与洞庭湖区纬度相近,为同一亚种)社鼠年龄组划分标准对应的体重指标,分成幼年组、亚成年组、成年组和老年组4个年龄组,对应的体重为:35g以下、35.1~50g、50.1~80.0g、80g以上。对3只没有体重记录的个体,则以其对应的体长标准判断其年龄组。从表3看见,雌性比最高的为幼年组,亚成年和成年组的雌雄比接近1:1,而老年组的雌性比为最低,雌鼠仅占33.3%。不同年龄组雌鼠宫角的发育情况,幼年组的宫角全部为细线状,亚成年组性成熟的比例为60.0%(宫角已发育成管状),成年组仅有极少数的仍为线状,老年组已100.0%的为管状。没有一只捕获的亚成年雌鼠宫角内有曾经怀孕留下的宫斑,其参产鼠应该都是第一次参与繁殖。

表3　不同年龄组雌性社鼠(洞庭湖区)宫角的发育状况

Table 3　The status of uterus of each age classes of *Niviventer confucianus* in Dongting Lake region

年龄组 Age classes	雌鼠数 No. of female	雌性比 Female ratio (%)	性成熟鼠数及其比例(%) Animals of sexually mature and its percentage in females	宫角有斑雌鼠数及比例(%) Animals of uterine scar and its percentage in females
幼年组 Juvenile	4	66.7	0(0.0)	0 (0.0)
亚成年组 Sub-adult	10	52.6	6 (60.0)	0 (0.0)
成年组 Adult	25	53.2	23 (92.0)	9 (36.0)
老年组 Old-adult	6	33.3	6 (100.0)	3 (50.0)

从表4看,幼年鼠中未见怀孕鼠,亚成年组有部分个体参与繁殖,到成年组怀孕率达到最高40.0%,老年组的怀孕率又有所下降。而参产率由幼年组的0%逐渐增加,到老年组稍有下降。不同年龄组间胎仔数存在明显的差异($F_{3,13}=10.888$, $p=0.002$),有随着年龄组增加,平均胎仔数明显增加的趋势。值得注意的是,老年组中捕获的2只怀孕鼠,其胎仔数都是所有怀孕雌鼠中最高的。以雌鼠计算的繁殖指数以老年组最高,而老年组中的雌鼠数明显降低,所以以所有鼠计算的繁殖指数以成年组最高,说明成年组是种群中繁殖的主体。

2.2　雄鼠繁殖特征

2.2.1　雄鼠繁殖特征的季节变化　以睾丸是否下降到阴囊(称"下位")作为雄鼠发育成熟或有能力参与繁殖的指标。本地区捕获的社鼠睾丸下位的最低体重为44g(胴体重32g)。睾丸腹位的最重鼠54g(胴体重37g),

睾丸腹位的最高胴体重 40g(体重 50g)。从表 5 看,社鼠的睾丸下位率全年总计为 75.6%,分四季平均为 86.0%,夏、秋季维持在较高水平,冬、春季稍低,低谷在春季。以所有鼠计,其睾丸重量及大小的(长径和短径)季节差异不显著;而仅以已下位的睾丸计,则有明显的季节变化,从其重量与大小看,具有春、夏、秋、冬逐渐下降的规律,春季与冬季相比,均有显著性差异,说明开春后,雄性社鼠在生殖器官已有明显变化。这些特征与雌鼠的繁殖高峰基本吻合。

表 4 不同年龄组雌性社鼠(洞庭湖区)的繁殖特征

Table 4 The reproductive characteristics of female *Niviventer confucianus* of each age group in Dongting Lake area

年龄组 Age classes	雌鼠数 No. of female	参产鼠数 No. of reproductive	参产率 Rate of reproductive (%)	孕鼠数 No. of pregnancy	雌鼠怀孕率 Rate of pregnancy (%)	平均胎仔数① Mean litter size (Mean ± SD)	繁殖指数 Index of reproduction($I_{♀}$)
幼年组 Juvenile	4	0	0.0	0	0.0	0	0.0
亚成年组 Sub-adult	10	2	20.0	2	20.0	2.5 ± 0.7 (2 ~ 3)	0.26 (0.50)
成年组 Adult	25	18	72.0	10	40.0	3.5 ± 0.8 (2 ~ 5)	0.74 (1.40)
老年组 Old-adult	6	4	66.7	2	33.3	6.0 ± 0.0 (6)	0.67(2.00)

①括号内的数值为胎仔数范围 The numbers in parentheses were change range of litter sizes

2.2.2 不同年龄组雄鼠的繁殖特征 从表 6 看,雄鼠睾丸下位率从幼年组到老年组逐步增加,从 0.0%到增加到 100.0%。其睾丸的重量和大小也呈同样的趋势,但亚成年组与幼年鼠间差异不显著,而亚成年组与成年组之间的睾丸重量和其长径与短径均有极显著性差异。说明雄性亚成年组到成体,性成熟方面确实已有质的变化。老年组与成年组睾丸大小有显著性的差异,而其重量却没有显著性变化。

表 5 雄性社鼠(洞庭湖区)繁殖特征的季节变化

Table 5 Reproductive characteristics of male *Niviventer confucianus* in each season

季节 Season	睾丸重 (Mean ± SD) Testis weight (g)	下降睾丸重 (Mean ± SD) Testis weight in scrotum(g)	睾丸大小 (Mean ± SD) Sizes of testis (mm)		下降睾丸大小(Mean ± SD) Sizes of testis in scrotum (mm)		下位率 (%) Rate of testes in scrotum
			长径 Long diameter	短径 Short diameter	长径 Long diameter	短径 Short diameter	
春季 Spring	0.976 ± 0.933ab	1.862 ± 0.262a	13.0 ± 6.0a (3 ~ 21)	7.3 ± 3.7a (2 ~ 12)	18.0 ± 1.6a (15 ~ 21)	10.3 ± 1.4a (8 ~ 12)	58.3 (14/24)
夏季 Summer	1.363 ± 0.374a	1.363 ± 0.374b	17.0 ± 3.4b (10 ~ 20)	9.9 ± 1.3b (8 ~ 12)	17.0 ± 3.4ab (10 ~ 20)	9.9 ± 1.3a (8 ~ 12)	100.0 (7/7)
秋季 Autumn	0.914 ± 0.262ab	0.914 ± 0.262bc	17.3 ± 3.0b (12 ~ 20)	9.3 ± 2.1ab (6 ~ 12)	17.3 ± 3.0ab (12 ~ 20)	9.3 ± 2.1ab (6 ~ 12)	100.0 (7/7)
冬季 Winter	0.668 ± 0.489b	0.791 ± 0.431c	12.1 ± 5.2ab (4 ~ 21)	6.7 ± 2.8a (2 ~ 11)	13.5 ± 4.1b (10 ~ 21)	7.5 ± 2.0b (6 ~ 11)	85.7(6/7)
方差分析(ANOVA) Variance analysis	0.849	11.458***	2.253	2.050	3.479*	4.145*	
合计 Total	0.988 ± 0.754	1.374 ± 0.549	14.2 ± 5.4 (3 ~ 21)	7.9 ± 3.2 (2 ~ 12)	16.8 ± 3.2 (10 ~ 21)	9.5 ± 1.9 (6 ~ 12)	75.6 (34/45)

每列中不同上标表示平均数间差异显著 The same superscript letters in same vertical row indicate no significant difference by t-test ($p > 0.05$), but different letters indicate significant different ($p < 0.05$); * $p < 0.05$, * * $p < 0.01$, and * * * $p < 0.001$ indicate the significant differences by variance analysis (ANOVA), the same below

表 6 雄性鼠各年龄组睾丸的变化

Table 6 Fluctuation of breeding stats of males in Dongting Lake region

年龄组 Age classes	样本数 Sample size	下位率 Rate of testis in scrotum (%)	睾丸重 (Mean ± SD) Testis weight (g)	长径 Long diameter (mm)		短径 Short diameter (mm)	
				范围 Range	平均数 ± 标准差 Mean ± SD	范围 Range	平均数 ± 标准差 Mean ± SD
幼年组 Juvenile	2	0.0	0.067 ± 0.018a	4 ~ 7	5.5 ± 2.1a	2 ~ 4	3.0 ± 1.4a
亚成年组 Sub-adult	9	33.3 (3/9)	0.096 ± 0.067a	3 ~ 15	7.8 ± 3.5a	2 ~ 8	4.4 ± 1.9a
成年组 Adult	22	86.4 (19/22)	1.190 ± 0.618b	6 ~ 21	15.5 ± 4.4b	3 ~ 12	8.5 ± 2.7b
老年组 Old-adult	12	100.0 (12/12)	1.738 ± 0.310b	16 ~ 20	18.5 ± 1.4c	9 ~ 12	10.6 ± 1.0c
方差分析(ANOVA) Variance analysis			13.291***		19.458***		16.965***

3　讨论

社鼠在洞庭湖区主要栖息在山区和丘陵地带的林地,此外仅局限于山边的农田。与洞庭湖区其它鼠相比,社鼠的胎仔数是较低的,平均仅为3.7只,皆低于当地的褐家鼠(8.05)[30],黄胸鼠(6.46)[31]、小家鼠(4.88)[32]、黑线姬鼠(5.3)[33]和东方田鼠(5.13)[34]。繁殖指数(1.15,以雌鼠计)也低于当地主要栖息于农田生态系统及农舍区的其它鼠种,如褐家鼠(1.46)[30]、黄胸鼠(1.34)[31]、小家鼠(2.15)[32]、黑线姬鼠(岳阳2.49;桃源与汉寿2.36)[33];并且也低于主要栖息于湖滩草地的东方田鼠(1.66)[34]。不同种类啮齿动物的繁殖指标会有不同,这是动物与环境长期相互作用的结果。社鼠种群的胎仔数应该与其栖息环境有关,它所选择的森林生境应该是其最适栖息环境。而其繁殖强度比当地生活在农田生态系统以及房舍内的其它鼠种均低。或许,农田生态系统中鼠类相对较高的胎仔数和繁殖强度是对人类经常干扰的一种适应。农田及农房内的鼠类种群经常受到人类活动的干扰,特别是经常性人为地控制种群数量(如杀灭、捕捉、改变栖息环境等),鼠类种群就会以维持较高的繁殖强度来弥补种群数量的损失为其适应对策。洞庭湖区东方田鼠以湖州草地为其最佳栖息地,但年年夏季受洪水淹没被迫迁至农田区,秋后再回迁,这也使得其种群处于不安定状态,需要在冬春繁殖盛期保持较高胎仔数。而与上述两类生境相比,社鼠栖息在林地,生活环境受人类干扰相对较少。林地的物种多样性较高,种群数量相对稳定,因此栖息于其中鼠类的胎仔数和繁殖指数就比农田生态系统中鼠类的低。就同一地区的同一鼠种而言,不同环境条件下,其胎仔数与繁殖强度也会存在差别。Pocock等[35]的研究也发现与人共生的小家鼠的繁殖强度比完全自然环境的要高。本研究区域,山区林地人烟稀少,郁闭度高;而丘陵林地高大乔灌木及林下灌草丛都不及山区林地浓密,其内常有人畜串行,干扰程度相对较高。利用本文资料,比较山区与丘陵林地两种生境的胎仔数和繁殖强度(表7),虽然样本数较少,但也有类似的结论,即受干扰较少的山区社鼠的胎仔数比丘陵区低,繁殖指数也相对较低。动物最优胎仔数应该是在后代数量和质量最大化的基础上,保证母体花费能量最少[36]。因雌鼠参与繁殖的过程,是最耗能量的过程[37~39],如布氏田鼠(*Microtus brandti*)哺育期代谢能摄入最高时达正常雌鼠的323%。母体投资量的增加,将会导致母体生存率的降低[37,40]。一般情况下,其最优生存环境的胎仔数应该为其种群最适胎仔数,而社鼠这种在种群干预程度更大的环境下的胎仔数更高的原因,应该是其种群对其环境适应的结果。

表7　不同生境社鼠(洞庭湖区)的繁殖特征

Table 7　The reproductive characteristics of female *Niviventer confucianus* in different habitat in Dongting Lake area

生境 Habitat	样本数 Sample size	雌鼠数 No. of female	雌性比 Female ratio (%)	孕鼠数 No. of pregnancy	雌鼠怀孕率 Rate of pregnancy (%)	平均胎仔数 Mean litter size (Mean ± SD)	繁殖指数 Index of Reproduction ($I_{♀}$)	雄鼠睾丸下位率 Rate of testis in scrotum (%)
丘陵 Hilly area	56	29	51.8	9	31.0	4.11 ± 1.36	0.56(1.28)	76.9
山区 Moutainous area	25	12	48.0	3	25.0	2.67 ± 0.58	0.32(0.67)	61.5

与其它地区的社鼠相比,洞庭湖区的平均胎仔数与相近纬度浙江金华社鼠的(3.77,范围3~5只)[26]相近。海南社鼠的胎仔数在3~5之间波动,其中年龄组Ⅱ和Ⅲ(仅分3个年龄组)的胎仔数分别为3~4和4~5[29]。而纬度较高的平均胎仔数,如北京社鼠(平均5.2,范围2~8只)[14]和天津地区(平均4.5,范围2~6)[25]的明显要高。这与张知彬等[41]对中国啮齿类繁殖参数的地理变异的分析结果相似,同一种鼠类在不同纬度的生殖强度会有不同,纬度高,繁殖季节短,胎仔数就高。

关于社鼠老年组的胎仔数较高的问题,这个现象在鲍毅新等[13]报道中也有出现,其老年组的胎仔数(7)比其它组(亚成年组3.67和成年组3.50)明显要高(表8),北京社鼠的胎仔数尽管差别不大,却仍以老年组为最高[14]。洞庭湖区的黄胸鼠中也曾有相同的现象[47],捕俘黄胸鼠的老年组中唯一怀孕的一只雌鼠胎仔数(14)较其它年龄组的都多。这是否是一种普遍现象,有待进一步研究。由于一般资料反映是统计后的平均数,对一些极端数据无从了解。表8列出了一些鼠种不同年龄组的平均胎仔数,有些也有同样的趋势,即老年组的平均胎仔数较多;有些似乎没有这种现象,这可能存在鼠种间或因环境导致的差异。值得注意的是,很少出现老年组胎仔数比其它年龄组明显减少的情况。将表8中各鼠种老年组与其亚成年组、成年组(成年Ⅰ和

表 8 不同鼠种各年龄组胎仔数比较①

Table 8 Litter sizes of different age classes of some rodents in China

鼠种 Rodent species	地点 Places	主要栖息生境 Habitats	亚成年组 Subadult	成年Ⅰ组 Adult Ⅰ	成年Ⅱ组 Adult Ⅱ	老年组 Old	资料来源 Resources
社鼠 *Niviventer confucianus*	北京 Beijing	林地 Forest	—	4.63 (40)	4.99 (40)	5.17 (12)	张洁[14]② Zhang Jie
	浙江 Zhejiang	林地 Forest	3.67(3)	3.5(4)		7(1)	鲍毅新等[13] Bao Yixin *et al*
	洞庭湖 Dongting lake region	林地 Forest	2.5(2)	3.7(10)		6(2)	本文 This paper
黑线姬鼠 *Apodemus agrarius*	桃源、汉寿 Taoyuan & Hanshou, Hunan	农田 Farmland	5.3 (83)	5.6 (126)	5.5 (128)	5.7 (51)	王勇等[33] Wang Yong *et al*
	岳阳 Yueyang, Hunan	农田 Farmland	5.1	4.9	4.8	4.8	陈安国等[30] Chen Anguo *et al*
	上海 Shangshai	农田 Farmland	5.40(40)	5.34(153)	5.59(148)	7.22(104)	祝龙彪等[42].② Zhu Longbiao *et al*
	淮北 Huaibei	农田 Farmland	5.2	5.5	5.2	5.5	朱盛侃等[43] Zhu Shengkai *et al*
东方田鼠 *Microtus fortis*	洞庭湖 Dongting lake region	洲滩 Beach of lake	4.22	4.77	5.45	5.71	武正军等[34] Wu Zhengjun *et al*
小家鼠 *Mus musculus*	新疆 Xingjian	农田 Farmland	6.56 (78)	7.88 (443)		7.77 (26)	严志堂等[44].② Yan Zhitang *et al*
	贵州 Guizhou	农房 Farmhouse	3.22(9)	4.71(55)	4.98(43)	5.33(3)	潘世昌[45] Pan Shichang
褐家鼠 *Rattus norvegicus*	贵州 Guizhou	农田、住宅 Farmland & house	5.67(6)	6.50(12)	7.13(8)	9.20(5)	杨再学等[46] Yang Zaixue *et al*
黄胸鼠 *Rattus flavipectus*	洞庭湖 Dongting lake region	农房、农田 Farmland & house	5.25 (4)	5.05 (17)	6.03 (20)	14 (1)	张美文等[47] Zhang Meiwen *et al*
黑线仓鼠 *Cricetulus barabensis*	山东 Sandong	农田 Farmland	7.0 (5)	6.4 (29)	5.6 (18)	6.4 (9)	卢浩泉等[48] Lu Haoquan *et al*
	淮北 Huibei	农田 Farmland	5.0	5.2	5.3	4.8	朱盛侃等[43] Zhu Shengkai *et al*
	鄂尔多斯 Ordos	草场 Grassland	6.21	5.82	5.68	5.33	董维惠等[49] Dong Weihui *et al*
大仓鼠 *Cricetulus triton*	淮北 Huibei	农田 Farmland	—	7.3	7.9	9.9	朱盛侃等[43] Zhu Shengkai *et al*
	陕西 shaanxi	农田 Farmland	8.1(22)	9.4(35)	9.2(16)	8.3(1)	李晓晨等[50] Li Xiaochen *et al*
长爪沙鼠 *Meriones unguiculatus*	内蒙古 Inner Mongolia	农作区 Farmland	—	5.15(17)	5.05(44)	5.12(26)	周庆强等[51].② Zhou Qingxiang *et al*
		草原区 Grassland	—	6.5(2)	5.71(52)	5.68 (25)	
黑腹绒鼠 *Eothenomys melanogaster*	浙江 Zhejian	山区林地与草甸 Forest & meadow in mountain	2.5(6)	2.0(7)		2.5(6)	鲍毅新等[52] Bao Yixin *et al*
黑线毛足鼠 *Phodopus sungorus*	内蒙古 Inner Mongolia	草原 Grassland	6.89(9)	6.80(40)		8.00(1)	董维惠等[53] Dong Weihui *et al*
达乌尔黄鼠 *Spermophilus dauricus*	山西 shanxi	农田 Farmland	4.5(16)	4.60(130)	4.62(81)	5.13(16)	王廷正等[54].② Wang Tingzheng *et al*
	陕西 shaanxi	农田 Farmland	4.57(14)	5.15(47)	5.43(33)	5.50(14)	
高原鼢鼠 *Myospalax baileyi*	四川若尔盖 Rouergai Sichuan	草原 Grassland	2.06(68)	2.56(108)	2.01(16)	2.50(2)	汪志刚等[55].② Wang Zhigang *et al*

①括号内的数字为样本数 The numbers in parentheses were sample size; ②由文献中数据加权平均计算而得 The litter size was calculated from information in reference paper

Ⅱ组合并)的胎仔数进行双尾成对 t 检验,均具有显著性差异(老年组-亚成年组:$t = 2.861$, $df = 19$, $p = 0.010$; 老年组-成年组:$t = 2.440$, $df = 23$, $p = 0.023$)。决定动物胎仔数的因素较多,各种因素的影响也视不同的研究对象而定[56~58],如有些报道母体的体重与鼠类的胎仔数呈正相关[56,59~61],而有些却不相关[62,63]。本文中的社鼠胎仔数与其母鼠体重有相关性($r = 0.631$, $df = 13$, $p = 0.021$),胎仔数与年龄组亦有显著相关

($r = 0.680$, $df = 13$, $p = 0.015$)。就同一地区的同一鼠种而言,应该是年龄组间的一些生理上的变化导致了这些差异。而老年组胎仔数的显著增加可能是老年鼠补偿其总体繁殖力下降的一种生理适应性。但由于老年组怀孕率较低,其总体繁殖强度并不一定维持在高位。

洞庭湖区社鼠的繁殖盛期(夏、秋季),与当地的主要鼠种亦不甚相同。当地大部分鼠种在上下半年各有一个繁殖高峰,受当地高温的影响,夏季的繁殖能力都会有一定的下降[30],然后一般在秋季形成另一个高峰[30]。这与其栖息环境有一定的关系,生活在森林中的社鼠受夏季炎热天气的影响相对较小,在夏季的繁殖指数为最高,可见其繁殖几乎不受高温的影响。而在冬季停止繁殖,可能是受冬季低温天气和食物条件的影响。北京的社鼠一般在3~4月份开始繁殖,9月份基本结束,10月份仅见到个别孕鼠[14]。在天津,社鼠的繁殖主要集中在春、夏两季,5~7月份为繁殖盛期(高峰在7月份),10~翌年2月份不繁殖[25]。在川西,雌性社鼠的繁殖也是在夏季[64],冬季亦停止繁殖。在浙江金华12月和翌年1月份未发现孕鼠,2~3月份仅有少量鼠进入繁殖[65]。而在海南南湾,因四季温差变化小,季节变化对社鼠种群的影响不大,无明显的繁殖期[29]。总的来看,冬季对社鼠种群繁殖的影响较大,而夏季高温天气的影响却较小。

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