崖沙燕（*Riparia riparia*）筑巢栖息地适宜性分析

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摘要：崖沙燕是穴巢鸟类，集群繁殖。近年来受气候变化和栖息地丧失的驱动影响，崖沙燕数量在整个繁殖范围内急剧减少。本文从自然环境条件和人类活动两个方面，分析崖沙燕筑巢栖息地适应性的影响因子，认为基质、植被、水域、食物、体外寄生虫是崖沙燕筑巢栖息地选择的重要指标，而人类活动在一定程度上加剧其栖息地的丧失，同时也创造出新的人造栖息地作为天然栖息地的补充。

关键词：崖沙燕，筑巢，栖息地，适宜性

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崖沙燕（*Riparia riparia*）是雀形目(*Passeriformes*) 燕科(*Hirundinidae*) 沙燕属（*Riparia*）长途迁徙鸟类，以中小型昆虫为食[1]，集群繁殖，繁殖期为每年4月底至8月[2]。在我国，崖沙燕有四个亚种：东北亚种（*R. r. ijimae*）、新疆亚种（*R. r. diluta*）、青藏亚种（*R. r. tibetana*）和福建亚种（*R. r. fokiensis*）[3]，分布于新疆、青海、四川以及中国南方的多数地区[4]。崖沙燕因具有重要的生态、科学、社会价值，已被我国列入《国家保护的有益的或者有重要经济、科学研究价值的陆生野生动物名录》。

近年来，崖沙燕种群在整个繁殖范围内都在急剧下降[5]，栖息地的丧失和退化是主要的驱动因子[6][7]。有研究发现在一个特定的河岸地点筑巢的崖沙燕数量有相当大的年度波动[8]，这可能是繁殖季节栖息地适宜性发生变化的结果。因此，本研究拟从环境因子和人为因素两个方面对崖沙燕筑巢地生境适宜性进行分析，旨在为保护和恢复崖沙燕筑巢栖息地提供重要依据。

1 繁殖崖壁

1.1 类型

崖沙燕通常选择新被侵蚀的河流、溪流、湖泊、水库、沿海、以及湿地低地的崖壁[9]~[11]，以减少捕食者访问[12]，并通过周期性洪水事件减少巢穴中寄生虫负荷[13]。

随着自然栖息地的丧失，崖沙燕也在人工结构中筑巢，如公路和铁路切割和建筑工程挖掘的断面等[2]，甚至在墙壁上的排水管道中[14]。其中，采石场是极为重要的筑巢地点[9]。在捷克，约有三分之一的崖沙燕筑巢区

域仍保持密集的采石活动[15]。聚集坑可以为崖沙燕提供同等的筑巢栖息地，在巢穴大小、雏鸟数量、总体繁殖成功率上并没有差异，且坑类雏鸟比湖岸雏鸟有更少的体外寄生虫[16]。

崖沙燕通常会避开在旧的洞穴中筑巢（通常在沙坑），因为它们有明显的缺点，比如体外寄生虫的增加[17]。新形成的巢穴并没有被体外寄生虫高水平感染，但随着巢穴群落年龄的增长，致病率可接近100%[17]。因此，崖沙燕必须重新定居到一个新的地方，或者在前一个繁殖季节没有留下明显标志的地方[18]。通常情况下，大多数崖沙燕会在第二年返回到10公里范围内进行繁殖[19][20]。

1.2 高度和坡度

河岸高度和坡度，与洞穴数量呈正相关[21]，可能是迁徙过程中的重要影响因素[22]。崖沙燕倾向于在垂直河岸筑巢[12]，优先选择斜坡最上面的三分之一处[23]~[25]，使自然繁殖巢不低于3m的垂直高度，最大限度地减少捕食者的进入[26]，如蛇和狐狸[12]。不过，我们在人造崖壁上发现了低于1m的崖沙燕巢穴，这可能与人类活动频繁，捕食者不易接近有关。

1.3 基质

土壤颗粒的粒径，是影响繁殖成功的一个重要因素[27]。崖沙燕虽然拥有广泛的土壤分布[28]，但首先会优先选择松散土质[15]，主要是粘土含量低于10%的中细砂[27]。因为，细至中砂粒渗透性和排水性较好，可以保持墙体的稳定，即使在有大量雨水渗透的季节也能保持干燥的隧道[29]。并且，松散沙土比紧凑土壤易于开挖，可以减少崖沙燕筑巢的能量成本。隧道长度通常是60-100厘米，直径约6厘米[30]。随着洞穴深度的增加，崖沙燕成功筑巢的几率增加[23]。较深的洞穴不仅可以防止雏鸟掉落，还有利于抵御捕食者，保护巢穴免受河岸表面塌陷的威胁[31]，提高崖沙燕繁殖成功率[23]。

另外，崖沙燕筑巢选址通常会避免底部有碎石堆积的地点[32]，因为它为捕食者提供了从下面轻松访问的路径[33]。

2 植被

植被的存在，被认为是繁殖崖壁或河岸（筑巢地）被遗弃的主要原因之一[15]。崖沙燕会选择未带植被的河岸面和基地，但除了大多数去除表层土壤的砾石坑，表层的土壤一般是有植被[31]。所以，崖沙燕更倾向于40米范围内没有超过1米植被的河岸

筑巢[31]。但有学者研究得出崖沙燕偏好选择植被密度较大与植被均较高的生境，且认为植被不是崖沙燕巢址选择的主要因子[34]。根据大量的实际调查发现，崖沙燕筑巢崖壁，通常是没有植被或分布有少量低矮植被，这与 Bergstrom[8]阐述的植被最少的观点基本一致。这可能是开阔空间有利于观察外界变化，及时发现潜在的危险，同时也减少捕食者栖息或潜伏的风险。另外，河岸下自然播种树木和灌木，是小的筑巢区域的典型威胁[15]。因此，植被状况是崖沙燕选址的重要指标。

3 水域

3.1 距离

崖沙燕种群的存在，其繁殖崖壁与水的距离呈负相关[35]。崖沙燕巢穴通常在靠近水体的地方被发现。大多数的巢穴群位于最近水域 500 米处，但也有位于水域 5 公里处[15]。崖沙燕的繁殖似乎更少依赖于水的存在[15]，曾在离巢穴 8-10 公里的地方才被发现[19]。崖沙燕选择水域筑巢，可以方便觅食、有效阻止捕食者的进入，而远离水域的原因很可能是没有适宜的河岸栖息地。

3.2 水流

繁殖地点附近发生的水流侵蚀现象，对于崖沙燕筑建新的巢穴至关重要。繁殖地点的适宜性，在一定程度上取决于侵蚀，因为侵蚀既会创造新的地点，也会破坏旧的地点[10]。自然变化的水流创造和维持了对河岸物种至关重要的栖息地动态[36]，为崖沙燕提供了一定数量的栖息地[11]。河流沿线最好的筑巢地点，是在每年发生侵蚀的曲线上[8]。随着时间的推移，栖息地的可用性也受到流量机制的调节[37]~[39]。一年一度的冲刷阻止植被的侵入，限制砾石碎片的沉积，且繁殖季节前冬季河流流量对种群筑巢率有积极影响[40]。如果没有这种自然侵蚀，河岸将稳定、硬化，并不再支持崖沙燕的筑巢繁衍[41]。持续时间最长的崖沙燕聚居区与区域侵蚀有关[41]。

4 食物

4.1 食源

崖沙燕在觅食陆生昆虫之前，优先觅食水生昆虫，并根据水生昆虫的生产力和时间来确定雏鸟所能获得的相对利益[42]。不过，由于水生昆虫相对于陆生昆虫的相对密度非常低[43]，崖沙燕更依赖于陆生昆虫[42]。陆生双翅目昆虫是崖沙燕繁殖季节的主要食物来源[43]，水生昆虫的贡献很

低[44]，且水生昆虫的可用性似乎随着离湖泊距离的增加而减少[42]。当河道内生境异质性得到改善，河道的重新蜿蜒，便会增加大型无脊椎动物的丰度[45]，但在周边都是高产牧场的筑巢区域，水生昆虫对崖沙燕的食源贡献依然不大[43]，牧场猎物可用性更高[43]。

崖沙燕在空中捕食昆虫[46]，以多种飞行昆虫为食。在水源附近筑巢的燕子，在夏季以摇蚊科和毛蚊科为食，而不是其他著名的水生昆虫，如星翅目、鳞翅目或毛翅目[44]。陆生栖息地的崖沙燕则以陆生双翅目（苍蝇）、鞘翅目（甲虫)、膜翅目（锯蝇、黄蜂、蜜蜂和蚂蚁）、半翅目（蝽类）为食[42]。昆虫是蛋白质、硫和钙等热量和营养物质的重要来源。营养需求对产蛋有一定的影响，主要的限制因素是用于蛋的形成和维护的钙[1]。鞘翅目和毛蚊科昆虫的钙浓度高于平均水平（分别为 3.8 和 3.9 mg g-1 干重）[30]，在产卵过程中被崖沙燕大量摄取[1]。

4.2 觅食地点

崖沙燕经常在河流侵蚀过程形成的河崖或河岸上筑巢[47]，表现出对与河流相关的食物供应的强烈依赖[48]，经常在河流水面上觅食[45]，但并不局限于此[14]，还包括草地和农田等[10]。草原也是燕子适宜的觅食栖息地[41]，因为开阔区域的热气流会将猎物带到空中[49]，便于空中捕食。随着种群距离草原的距离越来越近，崖沙燕种群的生存能力就越高[41]。与湖岸和内陆栖息地相比，农田支持更高的昆虫可利用性（空中和非空中昆虫），且湖岸小麦田的昆虫干重最高，内陆和湖岸玉米田的昆虫干重最低[42]。

4.3 觅食距离

繁殖穴的燕子是中心觅食者，在筑巢地 200-500 米的开放栖息地以空中昆虫为食[12][41]，以此降低觅食的通勤成本[6]。崖沙燕在喂养雏鸟时，倾向于在距离 50-200 米的范围内觅食[50]。随着雏鸟期的推移，为成长中的后代寻找食物的压力增加，觅食范围会增加[6]。崖沙燕会远离筑巢地觅食[51]~[53]，有部分崖沙燕会在距离筑巢区 2km 以上的，甚至到 15km 的地方觅食[6]，以弥补食物供应的匮乏[51][54]。

4.4 气候条件

天气对食物资源有一定的影响[55][56]。空中捕食者的食物（空中浮游生物）严格依赖于温度、降雨等天气参数[57][58]。因此，空中食虫动物极易受到恶劣天气条件的限制，例如，寒冷、潮湿的天气，不仅减少了飞虫

的数量，而且还损害了鸟类的觅食能力[56]。

在恶劣天气下，由于食物供应的变化，迫使成鸟去离巢穴更远的地方觅食[59][60]，消耗更多的能量[61]。当春季和初夏天气寒冷、潮湿和多风时，昆虫数量不会增加到非常高的水平，可能会造成繁殖期间死亡率较高[33]。

温度和降水（干旱）是影响食物丰度的重要因子[62]。环境温度对燕科的食物供应有相当大的影响[63][30]，与崖沙燕的觅食率密切相关[1]。昆虫活动随温度的升高而增加[64][65]，昆虫丰富度和物种丰富度也随之增加[65][66]。天气极端波动有可能影响昆虫的活动水平[54]。当温度较低时，崖沙燕需要更多的食物来维持正常的代谢需求。如果食物资源减少，它们可能需要花费额外的能量来获取。当食物条件较差时，崖沙燕往往会长时间觅食，觅食距离与昆虫数量和温度呈负相关[54]。

在繁殖季节，崖沙燕繁殖地的降雨，对生产力有重要影响[62]。在气候非常干燥地区，5 月到 10 月期间降雨的增加，可能会导致更多的潮湿地区、植被生长和大量的昆虫，从而给崖沙燕提供更多的觅食机会[62]。不过，强降雨抑制了成虫的飞行，减少了被空中觅食鸟类捕获的机会，降低了成鸟的觅食能力，从而影响雏鸟的生产力，并在较小程度上引起巢洞的坍塌[62]。另外，干旱通过减少开放水域的面积、抑制昆虫的数量[67]，也会对崖沙燕产生不利影响。

4.5 食物对繁殖的影响

食物供给对崖沙燕繁殖存在潜在影响[17]。鸟类通常会推迟产蛋，直到食物供应达到较高水平的丰度[68][69]、质量和稳定性[1]。对于燕子来说，在第一窝孵化的关键阶段最需要稳定的食物供应，这也是限制该物种早期产蛋的最终因素[1]。换言之，食物供应的稳定性，是影响繁殖时间的重要因素[68]。

崖沙燕依赖的食物昆虫，在 5 月初就有，因此崖沙燕能够更早地产蛋[1]。繁殖期通常是适时的，以确保雏鸟在巢内时有最大的食物丰度[69][70][71]。另外，空中食虫鸟类的雏鸟能够在恶劣天气时期减缓发育速度，并在进食条件改善时恢复正常的发育速度[68][72]~[74]，并通过上调其肠道功能，降低维持的能量成本和增加运动活动来积极应对食物短缺[75]。

5 寄生虫

由于大多数体外寄生虫是通过密切联系或实际的身体接触从一个个体转移到另一个个体[76]，所以，迁

徙物种的个体可能比非迁徙物种的个体更容易感染体外寄生虫和疾病[77]。寄生虫可以导致死亡，并对宿主的繁殖能力和生存产生负面影响[78]~[81]。

崖沙燕通常感染有一种或多种鸟虱、双翅目幼虫、跳蚤、螨虫和蜱虫等[76][82][83]体外寄生虫，可降低崖沙燕的繁殖成功率，也会降低雏鸟的体重[84]。

6 人类活动

任何涉及河岸（或崖壁）或减少侵蚀的土地利用活动，都会限制崖沙燕可用栖息地，如道路维护、挖掘、防洪、稳固河岸、改变河流流量和改变周围的土地利用等[87][88]。甚至越野车活动的干扰，也会导致崖沙燕栖息地的丧失[87]。而土地利用模式也会影响猎物的可食用性[89][90]。

6.1 河流渠化

河流渠化，被认为是崖沙燕最隐蔽、最长期的威胁[91]，会导致崖沙燕栖息地的丧失，是崖沙燕灭绝的主要因素[88]。渠道化，包括通过使用堤坝来控制洪水和安装抛石来限制河流的自然蜿蜒模式。抛石是一种护岸形式，沿着河岸的各个部分从上到下放置巨大的岩石，以减少侵蚀[22]。例如，1980 年，在红崖引水坝下游 2.4 公里的 2000 多个洞穴被抛石项目摧毁[87]。

6.2 建造水坝水库

水坝水库的建设，影响着下游水流流量和速度，引起河流曲流迁移和河岸侵蚀减少[92]，从而导致崖沙燕栖息地的丧失，这可能是崖沙燕数量下降的另一重要原因之一[11]。当水库蓄水较高时，会破坏河岸栖息地，导致种群数量明显减少[7]。

6.3 挖掘或关闭采石场

作为崖沙燕重要的人工繁殖区，采石场的密集开挖和搬迁（关闭采石场）也对崖沙燕巢穴构成威胁[15]。密集开挖，无法为崖沙燕在繁殖期提供稳定的挖掘断面；而放弃开采的地方也很快布满了植被，断面通常会在几年后崩塌，土壤也变得更加紧凑[15]，通常会导致穴居物种放弃这些繁殖崖壁[93][94]。

7 分析讨论

巢穴增加了繁殖成鸟探测和阻止潜在捕食者的能力[95][96]，崖沙燕作为穴巢鸟，受到掠食性压力较小[97]，但巢穴的可用性通常限制了洞穴筑巢鸟类的数量[98]。然而，受到气候变化和栖息地丧失的双重威胁[12][99]，可用的天然巢穴相应减少，崖沙燕种群数量大幅下降[100][101]。

栖息地适宜性与崖沙燕筑巢选址倾向密切相关。由于物理环境和生物环境的不断变化，适宜的筑巢条件发生变化，崖沙燕就会重新选择繁殖栖息地。然而，由于气候变化和人类活动的影响，自然栖息地的选择空间也不断被压缩，崖沙燕甚至在远离河岸的人造结构中筑巢。虽然与在湖岸筑巢相比，聚集坑中每个成功的巢能产出更多的雏鸟[16]。然而，聚集坑中不成功的巢穴的比例也较高，且随着季节的推移，聚集坑中的成鸟质量显著下降[16]，会影响繁殖后迁移的能力（即体重损失造成的遗留效应）[102]。因此，建议要加强自然栖息地的管理，保护高质量的河岸栖息地，减少水污染和生态系统退化。

食物是崖沙燕繁殖成功的重要保障之一。觅食栖息地的丧失和退化、以及随之而来的对食物供应的负面影响，被认为是对崖沙燕恢复的最大威胁之一[103][104]。因此，要减少农田杀虫剂的使用，增加周边野生植被，提高昆虫数量和物种丰富度[105]。

崖沙燕种群的存在与洪水风险呈正相关[35]，洪水流量的恢复有助于引导水生和河岸生态系统走向其以前的状态，并减少湿地和河岸植被的面积[37]，有利于崖沙燕繁殖成功。而水坝、河堤硬化等一系列河道工程，在一定程度上改变了河流对原有河岸的侵蚀，会造成河岸的不稳定和体外寄生虫的增加。因此，建议减少对河岸的硬化处理和水坝建设，拆除不必要的河堤或其他护堤设施[41]，恢复河流自然流量和流速。

恶劣的天气会增加返回迁徙期间或越冬地的死亡率[102]。崖沙燕是迁徙物种，其迁徙路线和越冬地区的天气条件可能与种群规模和存活率有关[106][107]。崖沙燕种群“崩溃”与越冬地区的极端干旱有关[107]，其数量的显著减少与越冬地降雨量非常低相吻合[108]。因此，在加强繁殖栖息地保护和恢复的同时，还应根据迁徙栖息地的降雨情况，采取有效措施，提高越冬季节成鸟和幼鸟的成活率，确保繁殖种群的数量，加快崖沙燕种群的恢复。

参考文献：

[1]Turner A. K..Timing of Laying by Swallows (*Hirundo rustica*) and Sand Martins (*Riparia riparia*).*Journal of Animal Ecology*,1982，51，29-46.

[2]BirdLife International. *Riparia riparia* (amended version of 2016 assessment). The IUCN Red List of Threatened Species，2019，e.T103815961A155536007.

[3]郑作新.中国鸟类系统检索.北京:科学出版社,2002,142-143.

[4]郑光美.中国鸟类分类与分布名录[M].3版.北京:科学出版社,2017.

[5]Sauer, J. R., D. K. Niven, J. E. Hines, D. J. Ziolkowski Jr, K. L.Pardieck, J. E. Fallon, and W. A. Link. The North American Breeding Bird Survey, results and analysis 1966-2015. Version 2.07, USGS Patuxent Wildlife Research Center, Laurel, Maryland, USA, 2017.

[6]Sarah Saldanha，Foraging and Roosting Habitat Use of Nesting Bank Swallows in Sackville, NB. Dalhousie University, Halifax, Nova Scotia,2016.

[7]苏化龙,胥执清,聂必红,等.三峡库区水库蓄水对崖沙燕种群的影响[J].动物学杂志,2007,(03):120-125.

[8]Bergstrom, E. A. . The South Windsor bank swallow colony. Bird-Banding,1951, 22(2), 54-63.

[9]Tucker G. M.; Heath, M.F.. Birds in Europe: Their Conservation Status. BirdLife International: Cambridge, U.K., 1994.

[10]Turner A.. Collared Sand Martin (Riparia riparia). In: del Hoyo, J., Elliott, A., Sargatal, J., Christie, D.A. and de Juana, E. (eds), Handbook of the Birds of the World Alive, Lynx Edicions, Barcelona,2004.

[11]Girvetz, Evan H. Removing erosion control projects increases bank swallow (Riparia riparia) population viability modeled along the Sacramento River, California, USA. Biological conservation, 2010, 143(4): 828-838.

[12]Garrison Barrett A.. Bank swallow (Riparia riparia). In A. Poole and F. Gill (Eds.):The Birds of North America, American Ornithologists' Union, Cornell Laboratory of Ornithology, Academy of Natural Sciences: Washington, DC, USA, 1999,414:1-20.

[13]Szép, t. and møllEr, A. p.. Exposure to ectoparasites increases within-brood variability in size and body mass in the sand martin. Oecologia, 2000,125: 201-207.

[14]Cramp S. (ed.). Handbook of the birds of Europe,the Middle East and North Africa. The birds of the Western Palearctic. Vol. V Tyrant flycatchers to thrushes. Oxford University Press:Oxford,1988.

[15]Heneberg P.. Sand martin (Riparia riparia) in the Czech Republic at the turn of the millenium. Linzer Biologische Beitraege, 2007,39(1):293-312.

[16]Burke, T. R., Cadman, M. D., & Nol, E. . Reproductive success and health of breeding Bank Swallows (Riparia riparia) in aggregate (sand and gravel) pit and natural lakeshore habitats. The Condor, 2019,121(4):duz050.

[17]Szép T. & Møller A.P.. Cost of parasitism and host immune defence in the Sand Martin Riparia riparia: A role for

parent-offspring conflict? Oecologia, 1999,119:9-15.

[18]Szabó Zoltán D. & Szép Tibor .Breeding dispersal patterns within a large Sand Martin (Riparia riparia) colony. J Ornithol ,2010,151:185-191.

[19]Mead, C. J. . Colony fidelity and interchange in the Sand Martin. Bird Study,1979,26:99-106.

[20]Szép T..Effects of age- and sex-biased dispersal on the estimation of survival rates of the sand martin Riparia riparia population in Hungary. Bird Study,1999,46:169－177.

[21]Humphrey, J. M., and B. A. Garrison.. The status of Bank Swallow populations on the Sacramento River, 1986. State of California, The Resources Agency, Department of Fish and Game, Wildlife Management Division, Administrative Report 87-1, Sacramento,1987.

[22]Moffatt Kerry C.. Colonization and extinction dynamics of Bank Swallow (Riparia riparia) colonies along the Sacramento River, California.UNIVERSITY OF CALGARY,CALGARY,2003

[23]Sieber O.. Kausale und funktionale Aspekte der Verteilung von Uferschwalbenbruten (Riparia riparia L.). Zeitschrift für Tierpsychologie,1980,52(1):19-56.

[24]Garrison, B. A., Humphrey, J. M., Laymon, S. A.. Bank swallow distribution and nesting ecology on the Sacramento river, California. Western Birds, 1987, 18:71-76.

[25]Heneberg P.. The influence of nestwall size on number and density of nestholes of Sand Martin (Riparia riparia). Sylvia, 1998,34:115-124.

[26]Silver, M. and Griffin, C. R.. Nesting habitat characteristics of bank swallows and belted kingfishers on the Connecticut river. Northeastern Naturalist, 2009,16: 519-534

[27]Heneberg P.. Size of sand grains as a significant factor affecting the nesting of Bank Swallows (Riparia riparia). Biologia, Bratislava,2001,56(2): 205-210.

[28]Heneberg P.. Soil particle composition affects the physical characteristics of Sand Martin Riparia riparia holes. *Ibis*,2003, 145:392-399.

[29]Bo-Bertil Lind, Jimmy Stigh & Lars Larsson. Sediment type and breeding strategy of the Bank Swallow *Riparia riparia* in western Sweden.ORNIS SVECICA, 2002, 12:157-163.

[30]Turner A. K.. The use of time and energy by aerial-feeding birds. Unpublished. Ph.D. thesis, University of Stirling,1980.

[31]Hjertaas Dale G.. Colony site selection in Bank Swallows. MSc Thesis, The University of Saskatchewan, Saskatoon,1984.

[32]Ghent, A. W.. Importance of low talus in location of bank swallow (Riparia riparia) colonies. American Midland Naturalist,2001,146:447-449.

[33]Mead, C. J.. Mortality and causes of death in British Sand Martins. Bird Study ,1979,26:107-112.

[34]叶淑英,郭书林,窦泽龙,王振龙,路纪琪. 郑州郊区崖沙燕(Riparia riparia) 的巢址选择.生态学报,2016,36(21) : 7006-7013.

[35]Jon Etxezarreta and Juan Arizaga. Charatceristics of Sand Martin Riparia riparia Colonies In Artificial River Walls.Ardeola , 2014, 61(1):127-134.

[36]Poff, N. L., Allan, J. D., Bain, M. B., Karr, J. R., Prestegaard, K. L., Richter, B. D., ... & Stromberg, J. C.. The natural flow regime. BioScience, 1997,47(11), 769-784.

[37]Greenberg L, Svendsen P, Harby A.. Availability of microhabitats and their use by brown trout (Salmo trutta) and grayling (Thymallusthymallus) in the River Vojman, Sweden. Regulated Rivers: Research & Management,1996,12: 287-303.

[38]Reeves GH, Benda LE, Burnett KM, Bisson PA, Sedell JR.. A disturbanee-based ecosystem approach to maintaining and restoring reshwater habitats of evolutionarily significant units of anadromous salmonids in the Pacific Northwest. American Fisheries Society Symposium,1996,17: 334-349.

[39]Sparks RE.. Need for ecosystem management of large rivers and their floodplains. BioScience ,1995,45: 168-182.

[40]Moffatt, K. C., Crone, E. E., Holl, K. D., Schlorff, R. W., & Garrison, B. A.. Importance of hydrologic and landscape heterogeneity for restoring bank swallow (Riparia riparia) colonies along the Sacramento River, California. Restoration Ecology, 2005,13(2), 391-402.

[41]Garcia, D.. Spatial and Temporal Patterns of the Bank Swallow on the Sacramento River. Environmental Science. California State University, Chico, CA.(M.S. thesis, California State University, Chico, CA, USA.),2009.

[42]Génier Corrine S. V.. Diet Composition and Mercury Exposure in Bank Swallows (Riparia riparia) Breeding at Lakeshore and Aggregate Pits. Electronic Thesis and Dissertation Repository,2019,6777.

[43]Nakano Daisuke, Akasaka Takumi , Kohzu Ayato & Nakamura Futoshi.Food sources of Sand Martins Riparia riparia during their breeding season: insights from stable-isotope analysis, Bird Study, 2007,54:1, 142-144

[44]Waugh, D.R.. The diet of Sand Martins during the breeding season. Bird Study, 1979, 26:123-128.

[45]Nakano, D., Nunokawa, M. & Nakamura, F.. Change in distribution and structure of macroinvertebrate community befor

e and after re-meandering experiment. Ecol. Civil Eng,2005,7: 173-186.

[46]Fry C. H., Ash, J. S. & Ferguson-Lees I. J.. Spring weights of some Palearctic migrants at Lake Chad. Ibis,1970,112(1): 58-82.

[47]Morgan, R.A.. Sand Martin nest record cards. Bird Study,1979,26:129-132.

[48]Szép T.,Z. Szabó D. and Vallner J.. Integrated population monitoring of sand martin Riparia riparia---an opportunity to monitor the effects of environmental disasters along the river Tisza .Ornis Hungarica,2003,12-13: 169-182.

[49]Drake, V.A. & Farrow, R.A.. The influence of atmospheric structure and motions on insect migration. Ann. Rev. Entomol. 1988,33:183-210.

[50]Garrison, B. A.. Bank Swallow, California Partners in Flight Riparian Conservation Plan,2002(available from: http://www.prbo.org/calpif/htmldocs/species/riparian/bansacct.html). Cited from Kerry C. Moffatt, Colonization and extinction dynamics of Bank Swallow (Riparia riparia) colonies along the Sacramento River, California.University of Calgary, Calgary,2003.

[51]Adams, J. S., Knight, R. L., McEwen, L. C. and George, T. L.. Survival and growth of nestling Vesper Sparrows exposed to experimental food reductions. The Condor, 1994,96 (3): 739-748.

[52]Falconer, C. M., Mallory, M. L. and Nol, E.. Breeding biology and provisioning of nestling Snow Buntings in the Canadian High Arctic. Polar Biology, 2008,31(4): 483-489.

[53]Sokolov, V., Lecomte, N., Sokolov, A., Rahman, M. L. and Dixon, A.. Site fidelity and home range variation during the breeding season of Peregrine Falcons (Falco peregrinus) in Yamal, Russia. Polar Biology , 201437 (11): 1621-1631.

[54]Bryant, D. M. and Turner, A. K.. Central place foraging by swallows (Hirundinidae): the question of load size. Animal Behaviour, 1982 30 (3): 845-856.

[55]Lack, D.. Population Studies of Birds. Oxford University Press, Oxford,1966.

[56]Elkins, N.. Weather and bird behaviour. T. & A. D. Poyser, Carlton,1983.

[57]Koskimies J.. The life of the swift Micropus apus (L.) in relation to weather. Ann. Acad. Sci. Fenn.,1950,A 4: 1-151.

[58]Brown C. R. & Brown M. B. Natural selection on tail and bill morphology in Barn swallows Hirundo rustica during severe weather. Evolution,1999,52: 1461-1475.

[59]Turner, A. and Rose, C.. Swallows and martins: an identification guide and handbook. Houghton Mifflin Co: Boston, 1989.

[60]Winkler, D. W.. Roosts and migrations of swallows. El hornero, 2006 ,21 (2): 085-097.

[61]Westerterp, K. R., and D. M. Bryant.. Energetics of free existence in swallows and martins, Hirundinidae, during breeding. A comparative study using doubly labeled water. Oecologia,1984, 62:376-381.

[62]Edward Cowley and Gavin M. Siriwardena. Long-term variation in survival rates of Sand Martins Riparia riparia: dependence on breeding and wintering ground weather, age and sex, and their population consequences.Bird Study,2005,52:237-251.

[63]Bryant, D. M.. The factors influencing the selection of food by the house martin, Delichon urbica. Journal of Animal Ecology, 1973,42:539-564.

[64]Haskell, P. T.. Insect Behaviour. Adlard and Son, Ltd. Bartholomew Press, Dorking, Surrey ,1966.

[65]Taylor, L. R.. Analysis of the effect of temperature on insects in flights. Journal of Animal Ecology,1963,32:99-117.

[66]Turner, A.K. Time and energy constraints on the brood size of swallows, Hirundo rustica, and sand martins, Riparia riparia.Oecologia 1983,59, 331 - 338.

[67]Zwarts, L., Bijlsma, R.G., van der Kamp, J. & Wymenga, E.. Living on the Edge: Wetlands and Birds in a Changing Sahel. Zeist, The Netherlands: KNNV Publishing,2009.

[68]Bryant, D. M.. Breeding biology of the house martin, Delichon urbica, in relation to aerial insect abundance. Ibis,1975,117:180-215.

[69]Perrins C. M.. The timing of birds' breeding seasons. Ibis,1970,112:242-256.

[70]Gibb, J.. The breeding biology of the Great and Blue Titmice. Ibis,1950,92:507-539.

[71]Lack D.. The Natural Regulation of Animal Numbers. Oxford University Press: Oxford,1954.

[72]Lack, D & Lack, E.. The breeding biology of the Swift Apus apus. Ibis,1951, 93 501-546.

[73]O' Connor, R.J.. Nest-box insulation and the timing of laying in the Wytham Woods population of Great Tits Parus major. Lbis,1978,120:534-536.

[74]Emlen, S. E., Wrege, P. H., Demong, N. J. and Hegner, R. E. .

Flexible growth rates in nestling white-fronted bee-eaters: a possible

adaptation to short-term food shortage. Condor,1991,93, 591 - 597.

[75]Brzek, P., & Konarzewski, M. Effect of food shortage on the physiology and competitive abilities of sand martin (*Riparia riparia*) nestlings. *Journal of Experimental Biology*, 2001,204(17): 3065-3074.

[76]Rothschild, M., and T. Clay. Fleas, flukes, and cuckoos. A study of bird parasites. Macmillan Press: New York, 1957, xiv + 305 p..

[77]John L. Hoogland & Paul W. Sherman. Advantages and Disadvantages of Bank Swallow (Riparia Riparia) Coloniality. Ecological Monographs,1976,46: 33-58.

[78]Møller, A. P. . Effects of parasitism by a haematophagous mite on reproduction in the Barn Swallow. Ecology,1990, 71:2345 - 2357.

[79]Hudson, P. J., and A. P. Dobson. Host - parasite processes and demographic consequences. In Host - Parasite Evolution, General Principles and Avian Models (D. Clayton and J. Moore, Editors). Oxford University Press, Oxford, UK. ,1997, 128 - 154.

[80]Danchin, E., T. Boulinier, and M. Massot. Conspecific reproduction success and breeding habitat selection: Implications for the study of coloniality. Ecology,1998,79:2415 - 2428.

[81]Proctor, H. C.. Feather mites (Acari: Astigmata): Ecology, behavior, and evolution. Annual Review of Entomology, 2003,48:185 - 209

[82]Stoner D.. Studies on the Bank Swallows Riparia riparia riparia (Linnaeus) in the Oneida Lake region. Roosevelt Wild Life Bull,1936, 4:122-233.

[83]Büttiker W.. Parasiten und nidicolen der Uferschwalbe. Mitt. Schweiz. Entomol. Ges.,1969, 42:205-220.

[84]Santos Alves M. A.. Effects of ectoparasites on the Sand Martin Riparia riparia nestlings. IBIS, 1997,139:494-496.

[85]Hubble, T., and E. De Carli. Mechanisms and Processes of the Millennium Drought River Bank Failures: Lower Murray River, South Australia, Goyder Institute for Water Research Technical Report Series No. 15/5, Adelaide, South Australia,2015.

[86]Freer, v. M.. factor affecting site tenacity in New York Bank Swallows. Bird Banding, 1979,50: 349-357.

[87]Stephen A. Laymon, Barrett A. Garrison and Joan M. Humphrey. Historic and current status of the bank swallow incallifornia,1987. Wildlife Management Division Administrative Report 88-2.Supported by California Endangered Species Tax Check-off Program, Nongame Bird and Mammal Section, California Department of Fish and Game.

[88]Moffatt, K. C.. Colonization and extinction dynamics of bank swallow (Riparia riparia) colonies along the Sacramento River.University of Calgary California,2005.

[89]Benton, T. G., D. M. Bryant, L. Cole, and Q. P. Crick-Humphrey.Linking agricultural practice to insect and bird p

opulations: a historical study over three decades. Journal of Applied Ecology, 2002,39:673 - 687.

[90]Brown, C. R., C. M. Sas, and M. Bomberger Brown.Colony choice in Cliff Swallows: effects of heterogeneity in foraging habitat. Auk,2002, 119:446 - 460.

[91]Remsen, J. V., Jr. Bird species of special concern in California: An annotated list of declining or vulnerable bird species. Nongame Wildl. Invest., Wildl. Mgmt. Branch Admin. Rep.,1978,78-1, 54.

[92]Larsen, E.W., Fremier, A.K., Greco, S.E.. Cumulative effective stream power and bank erosion on the Sacramento River, California, USA. Journal of the American Water Resources Association, 2006, 42, 1077-1097.

[93]Heneberg P. & K. ŠIMEČEK. Nesting of European bee-eaters (Merops apiaster) in Central Europe depends on the soil characteristics of nest sites. Biologia, Bratislava, 2004,59: 205-211.

[94]Hsiao-Wei Yuan , D. Brent Burt, Lee-Ping Wang, et al. Colony site choice of blue-tailed bee-eaters: influences of soil, vegetation, and water quality. Journal of Natural History,2006,40(7-8): 485-493.

[95]Finch, D. M.. Relationships of surrounding riparian habitat to nest-box use and reproductive outcome in House Wrens. The Condor,1989,91(4), 848-859.

[96] Pingjun Li, Thomas E. Martin.Nest-Site Selection and Nesting Success of Cavity-Nesting Birds in High Elevation Forest Drainages.The Auk,1991,108(2,):405-418.

[97]TE Martin, P Li - Ecology.Life history traits of open - vs. cavity - nesting birds.Ecology,1992, 73(2):579-592.

[98]Stauffer, D. F., & Best, L. B.. Nest-site selection by cavity-nesting birds of riparian habitats in Iowa. The Wilson Bulletin,1982,329-337.

[99]del Hoyo J., Elliott A. & Christie D. 2004. Handbook of the birdsof the world. Vol. 9: Cotingas to pipits and wagtails. LynxEdicions, Barcelona.

[100]Cowley E.. Sand Martin population trends in Britain,1965-1978. Bird Study, 1979,26: 113 - 116.

[101]Jones G.. Selection against large size in the Sand Martin. Ibis,1987,129: 274 - 280.

[102]Harrison, X. A., Blount, J. D., Inger, R., Norris, D. R., & Bearhop, S.. Carry-over effects as drivers of fitness differences in animals. Journal of Animal Ecology,2011, 80(1), 4-18.

[103]Cosewic.Committee on the Status of Endangered Wildlife in Canada. Cosewic assessment and status report on the Bank Swallow (Riparia riparia) in Canada. Ottawa, ON,Canada., 2013. http://www.registrelep-sararegistry.gc.ca/virtual_s

ara/files/cosewic/sr_hirondelle_rivage_bank_swallow_1213_e.pdf

[104]Falconer, M., K. Richardson, A. Heagy, D. Tozer, B. Stewart, J. McCracken, and R. Reid. Recovery Strategy for the Bank Swallow (Riparia riparia) in Ontario. Ontario Recovery Strategy Series. Prepared for the Ontario Ministry of Natural Resources and Forestry, Peterborough, ON, Canada,2016.

[105]Denys, C., & Tscharntke, T.. Plant-insect communities and predator-prey ratios in field margin strips, adjacent crop fields, and fallows. Oecologia, 2002,130, 315-324.

[106]Kuhnen K.. Bestandsentwicklung, Verbreitung, Biotop und Siedlungsdichte der Uferschwalbe (Riparia riparia) 1966-1973 am Niederrhein. Charadrius,1975,11: 1 - 24.

[107]David M. Bryant & Gareth Jones. Morphological changes in a population of Sand Martins *Riparia riparia* associated with fluctuations in population size. *Bird Study*,1995, 42(1): 57-65.

[108]Szep Tibor. Relationship between west African rainfall and the survival of central European Sand Martins *Riparia riparia*. *IBIS*,1995,137(2): 162-168.