

# MICE AS STOWAWAYS?

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## INTRODUCTION

Following the latest glaciation, Northwestern European islands including e.g. British and Danish isles were part of the continent. This made it possible for mammal species to cross the land unhindered before postglacial sea levels arose, ~10 300-8000 BP.

Small mammal species, like the striped field mouse (*Apodemus agrarius*) originally inhabiting the steppe landscapes of Eastern Europe, probably colonized Northwestern Europe following the agricultural expansion during the Neolithic period <6500 years BP. But fossil records from Southwestern France dating ~19 417±19 044 BP imply a westward expansion of striped field mouse into Europe before the Neolithic period indicating a possible old colonization history of Northwestern Europe.

After extensive atlas mapping of mammal distribution in Denmark in 2000-2005, the striped field mouse (*Apodemus agrarius*) was declared extinct on the Danish mainland but abundant on the two southern isles Lolland and Falster. However, in 2009-2010 the Natural History Museum, Aarhus received information of sightings of striped field mice including a dead striped field mouse from a mainland site, Filskov in Central Jutland. Therefore trapping was initiated in the area by the museum, which resulted in the discovery of a small population of striped field mice thriving in an area of 10 to 20 km around Filskov. The conclusion was that the population was isolated as the nearest neighbours in Germany were approximately 200 km away.

Was this population a remnant from an early colonization event pre sea level rise? Or an unintentional introduction by humans? In the latter case, when did the colonization or introduction take place?

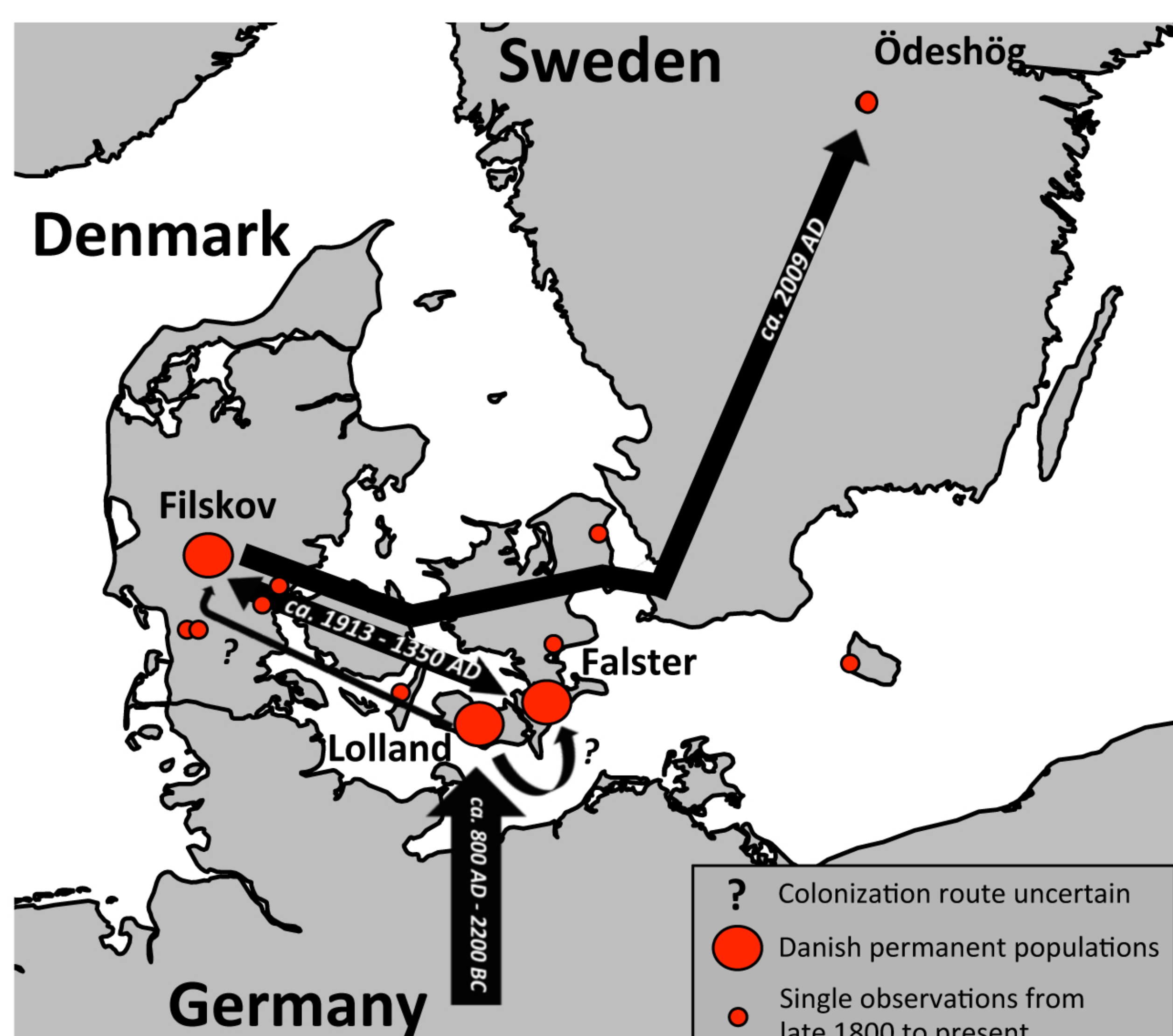
## METHODOLOGY AND ANALYSIS

In order to answer the question we wanted to unravel the total colonization history of the striped field mouse to Denmark.

We wanted to distinguish between a colonization event before 10 300-8000 BP when the two isles were still connected with Northwestern Europe and a colonization event around the Sub-Atlantic period (2500-0 BP) suggesting anthropogenic introduction. Furthermore, we wanted to know the origin of both the population in Central Jutland and a newly discovered occurrence of striped field mice from Sweden from which we had a single individual.

We sequenced whole mitochondrial genomes (mitogenomes) from 86 individuals of the striped field mouse representing Denmark, Germany, Poland, Estonia and Sweden to address the questions when and how this species colonized the Danish isles of Lolland and Falster and the area in Central Jutland.

Please see supplementary leaflet for the full description of the DNA analyses.



IMA results. Divergence time values are calibrated from 2010. Values in brackets denote 90% High Point Density (HPD) intervals.

$\mu$	Pop 1	Pop 2	$N_e$ , population 1	$N_e$ , population 2	$N_e$ , ancestral population	$m_1$	$m_2$	Divergence time BP (90% HPD)	Divergence time calibrated from 2010 (90% HPD)
3.2 × 10 <sup>-8</sup> subst/site	Filskov	Falster	15288 (4385-144703)	5570 (1067-74781)	6044 (3437-10785)	NA	NA	192 (97-311)	1818 AD (1913 AD - 1699 AD)
	Filskov	Lolland	9571 (5619-16856)	24218 (12671-55216)	7866 (3991-16158)	NA	NA	834 (562-1142)	1176 AD (1448 AD - 868 AD)
	Falster	Lolland	5434 (2473-11286)	20213 (10945-42786)	1620 (28-4691)	NA	NA	796 (571-1098)	1214 AD (1439 AD - 912 AD)
	Germany	Falster	79680 (38195-202991)	3862 (1860-8154)	16737 (8726-34762)	NA	NA	1587 (1157-1970)	423 AD (853 AD - 40 AD)
	Germany	Lolland	79440 (36788-216283)	15817 (9664-28613)	17594 (9419-33944)	NA	NA	1492 (1198-1872)	518 AD (812 AD - 138 AD)
	Germany	Filskov	72150 (33388-195928)	8958 (5049-15472)	22313 (12215-43485)	NA	NA	1554 (1111-1984)	456 AD (899 AD - 26 AD)
	Poland	Lolland	23588 (13104-48443)	15133 (9215-25617)	3297 (85-82937)	NA	NA	5826 (3736-7662)	3816 BC (1726 BC - 5652 BC)
	Poland	Falster	24546 (13557-50943)	3763 (1732-7465)	1851 (60-52616)	NA	NA	5637 (3571-7264)	3627 BC (1561 BC - 5254 BC)
	Poland	Filskov	23584 (9867-69772)	8328 (4829-14346)	30722 (16446-63473)	NA	NA	1012 (595-1405)	998 AD (1415 AD - 605 AD)
	Denmark	Mainland	21730 (15044-30803)	101484 (58025-195089)	37489 (23640-23640)	NA	NA	1252 (980-1582)	758 AD (1030 AD - 428 AD)
	Denmark	Mainland	19819 (13611-28416)	76173 (45608-146376)	28416 (239-336450)	0.005	0.025	1896 (902-NA)	114 AD (1108 AD - NA)
	1.5 × 10 <sup>-8</sup> subst/site	Filskov	Falster	32614 (9355-308700)	11883 (2275-159533)	12894 (7332-23007)	NA	NA	409 (208-664)
Filskov		Lolland	20418 (11986-35959)	51665 (27031-117795)	16781 (8514-34471)	NA	NA	1778 (1199-2436)	232 AD (811 AD - 426 BC)
Falster		Lolland	11593 (5276-24077)	43121 (23350-91276)	3457 (61-10007)	NA	NA	1698 (1218-2343)	312 AD (792 AD - 333 BC)
Germany		Falster	169984 (81483-433048)	8240 (3967-17395)	35706 (18616-74158)	NA	NA	3385 (2467-4203)	1375 BC (457 BC - 2193 BC)
Germany		Lolland	169472 (78480-461404)	33743 (19336-61040)	37534 (20094-72414)	NA	NA	3183 (2555-3993)	1173 BC (545 BC - 1983 BC)
Germany		Filskov	153919 (71227-417980)	19110 (10771-33008)	47600 (26059-92769)	NA	NA	3315 (3171-4233)	1305 BC (561 BC - 2223 BC)
Poland		Lolland	50320 (27956-103346)	32284 (19659-54649)	7034 (180-176933)	NA	NA	12429 (7970-16346)	10419 BC (5960 BC - 14536 BC)
Poland		Falster	52365 (28922-108679)	8027 (3695-15926)	3950 (127-112246)	NA	NA	12025 (7619-15496)	10015 BC (5609 BC - 13486 BC)
Poland		Filskov	50312 (21050-148846)	17766 (10301-30605)	65540 (35084-135410)	NA	NA	2158 (1270-2997)	148 BC (740 AD - 987 BC)
Denmark		Mainland	46356 (32093-65714)	216500 (123787-416189)	79978 (50432-50432)	NA	NA	2670 (2091-3374)	660 BC (81 BC - 1364 BC)
Denmark		Mainland	42281 (29036-60620)	162502 (97298-312269)	60620 (509-717760)	0.005	0.025	4045 (1925-NA)	2035 BC (85 AD - NA)

†: Highest 90% HPD interval could not be estimated due to multiple low peaks in the probability surface.

## CONCLUSION

Analyses of the phylogeny and genetic variation suggested a rather recent founding of the southern Danish isles, although the exact source population could not be inferred. Estimation of divergence time implied that these Danish populations were founded during the Sub-Atlantic or Sub-Boreal period. The estimated time periods overlap with Late Neolithic, Bronze, Pre-Roman and German Iron age (2223BC-899AD), which embraces a period of human migration and introduction of agriculture. Extensive human interaction and ship trade within northern Europe and across the Baltic Sea characterized these periods. This suggests that the colonization was anthropogenic induced probably through transport of food and hay on ships whereby mice unintentionally became stowaways.

Afterwards, the population in Central Jutland diverged from the island population of Falster only ~100-670 years ago, again probably favored by human introduction, either by ships or wagons or, if the introduction first occurred in the last part of the interval, by train or truck.

The Swedish individual from Ödeshög matched one haplotype from Central Jutland. Historically, the striped field mouse was not a part of the Swedish fauna and this suggests a founding from Central Jutland. Trading of potatoes is known to have occurred between the areas ~2009 and anecdotal stories of striped field mice on the sorting conveyor belt amongst potatoes from Central Jutland supports this conclusion.

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