Method	Brandname	Stage	Results	Implications - Concerns	Publications
Immuno-contraception					
pZP	ZonaStat-H	numerous studies (especially Assateague Isl.); used in the field; EPA registered	4 injections given in 2-4 week intervals + 6-10 months after last injection (n=10) resulted in 10-20% pregnancy rates	minimum of 2 inoculations is required in horses in order to raise sufficiently high antibody titers for a minimum of 6 months; horses may become difficult to access after numerous treatments	Liu et al. (1989) J Reprod Fertil 85:19-28
			2 injections (n=8) resulted in pregnancy rates of 12%; 3 injections (n=18) resulted in pregnancy rates of 0% compared to 45% for untreated mares (n=11)	booster doses result in a more robust immune response	Kirkpatrick et al. (1990) Wildl Soc Bull 18:326-330
			3 years of consecutive treatments (n=10) is >90% effective in preventing pregnancy compared to a 55% pregnancy rate in untreated mares (n=20)	prolonged treatment may interfere with ovarian function (based on depressed estrogen secretion)	Kirkpatrick et al. (1992) J Reprod Fertil 94:437-444
			treatment for 1-2 years (n=11), >3 years (n=19), or no treatment (n=42) resulted in significant ($p<0.05$) differences in longevity, with contracepted mares living longer	treated mares are healthier & live longer because they don't have to give birth & lactate; a consideration for population modeling	Kirkpatrick et al. (2007) Zoo Biol 26:237-244
	SpayVac	3 studies completed; EPA registration underway	single injection (n=12) resulted in pregnancy rates of 0, 17, 17 & 17% compared to 75, 75, 88 & 100% for controls (n=8) 1-4 years post-vaccination, respectively	initial trial with promising results for single injection (no boosters); study ended after year 4	Killian et al. (2008) Wildl Res 35:103-115
			3-4 months post-single injection (n=14) 93% of mares stopped cycling based on lower serum progesterone ($p<0.025$) & smaller ovaries ($p<0.001$) compared to controls (n=7)	originally designed as a safety trial requested by BLM; demonstrated that pZP may act in different ways (not just antibody-binding) - confirmed by Joone et al. (2017) Equine Vet J 49:189-195 in pony mares using ZonaStat	Bechert et al. (2013) J Wildl Manage 77:1386-1400
			single injection (n=30) resulted in foaling rates of 13, 47 & 43% compared to 100, 98 & 100% in controls 1-3 years post-vaccination, respectively (SpayVac VacciMax formulation)	vaccinations were given in rump, unlike Killian et al. (2008) & Bechert et al. (2013) studies, which administered vaccines in the neck closer to major lymph nodes	Roelle et al. (2017) Wildl Soc Bull 41:107-115 Bechert & Fraker (2018) Human-Wildl Interact 12:117-130
			IgG1 antibodies higher in infertile treated mares, especially IgG4/7 ($p<0.05$), compared to fertile treated mares from Roelle study	IgG4/7 provides long-lasting immunity compared to other IgG isotypes	Bechert et al. (2018) Theriogenology 121:168-174
	PZP-22	3 studies completed	injections of pZP + PLGA copolymer pellets generated antibody titers similar to ZonaStat + booster at 3-4 weeks; titers remained elevated for almost 11 months	pellets eliminated the need for a booster 3-4 weeks after initial vaccination with ZonaStat	Liu et al. (2005) Reproduction 129:181–190
			injections of pZP + QS-21 pellets (n=96) resulted in fertility rates of 6, 14, 32, and 48% for 1-4 years post-injection, respectively compared to 54% for untreated mares	contraceptive efficacy was effective for two breeding seasons (22 months post-injection)	Turner et al. (2007) J Wildl Manage 71:662-667
			remote dart injection of 100 µg pZP vaccine + 450 µg pZP in QA pellet resulted in foaling rates of 12 & 35% (n=17) compared to 56 & 54% in untreated mares (n=27, 26); significant for 1st year	remote delivery is effective for 1 year	Carey et al. (2019) Wildl Res 46:713-718
GnRH	GonaCon	3 studies completed; EPA registered	single injection with 1800 ug GnRH (n=11) or 2800 ug GnRH (n=4) resulted in pregnancy rates of 7, 36, 43, and 57% compared to 75, 75, 88 & 100% for controls (n=8) 1-4 years post-vaccination, respectively	AdjuVac was the adjuvant (same as for the SpayVac used in this study); GnRH is smaller than pZP so it may be harder to elicit an immune response	Killian et al. (2008) Wildl Res 35:103-115
			single injection (n=29) resulted in foaling rates of 64% and 69% compared to controls during 2 and 3 years post-vax, respectively		Baker et al. (2017) Proc 8th Intl Conf Wildl Fertil Control
			single injection (n=26 to 28) resulted in foaling rates of 46, 56 and 69% compared to 73, 78 & 67% for controls (n=26 to 27) during 2-4 years post-vaccination, respectively -- a booster 4 years later (n=25) resulted in foaling rates of 0 and 16% compared to 84% for controls 1-2 years post-vaccination, respectively	boosters have a very positive impact on vaccine efficacy	Baker et al. (2018) PLOS One 13(7): e0201570

Method	Brandname	Stage	Results	Implications - Concerns	Publications
BMP-15 & GDF-9	n/a	1 study completed & 1 underway; experimental	vaccination with either GDF-9 or BMP-15 + boosters at 6, 12 and 18 weeks had no effect on ovulation for GDF-9 (n=10) but was less (p=0.02) for BMP-15 (n=10)	GDF-9 decreased average follicle size & altered estrous behavior; BMP-15 decreased average follicle size, altered estrous behavior & decreased number of ovulations	Davis et al. (2018) Ani Reprod Sci 192:69-77
			treated (n=16) and control (n=16) mares will be naturally bred to test contraceptive efficacy for 3 years after a single injection of BMP-15/GDF-9 in liposomes made by SpayVac-for-Wildlife	results will demonstrate actual contraceptive efficacy	
Hormone Implants					
estradiol and/or progesterone in silastic rods	n/a	experimental	silastic rods containing ethinylestradiol, estradiol-17β, or progesterone were implanted into feral mares ranging from 4-10 years old; fertility rates were 12-22%; mares that were pregnant when treated carried their pregnancies to term	implanting silastic rods is more invasive than simple inoculations; there is some, albeit limited, potential that the hormones could enter the food chain if treated mares are killed and eaten by predators and scavengers	Plotka et al. (1992) J Wildl Dis 28:255-262 Eagle et al. (1992) Wildl Soc Bull 20:211-216
testosterone propionate	n/a	experimental	foal counts for control bands averaged 0.371 foals per mare, whereas for treated bands (n=10) the average was 0.066	must be hand-injected because of viscosity, which requires immobilization of stallions	Kirkpatrick et al. (1982) J Equine Vet Sci 2(4):114-118
Surgical					
ovariectomy	n/a	used experimentally and once in the field	ovariectomized by colpotomy (n=102) in 2010-11; 8 died pre-release; release occurred 3-8 days post-procedure; aerial surveys done post-release	mares & stallions were treated over an 8-year time period with removals conducted at the same time, making it difficult to evaluate specific treatment effects	Collins & Kasbohm (2017) J Wildl Manage 81(2):289-296
castration	n/a	used with domestic horses	vasectomized (n=137), chemically epididymectomized (n=126), castrated (n=5); aerial surveys done post-release	peak foaling rates for Sheldon (study site) were 11.4, 5.4, 5.4 (avg 7.4) compared to Massacre Lake HMA 13.0, 3.3, 6.5 (avg 7.6) for 2010, 2011, 2014	(same study)
Physical					
IUD	n/a	used experimentally	silastic O-ring-shaped IUDs (n=6) resulted in pregnancy rate of 0% compared to 100% for controls (n=12) for 1 year; IUD fell out of 1 treated mare prior to removal in year 2	contraceptive efficacy only tested for 1 year	Daels and Hughes. (1995) Theriogenology 44:629-639
	n/a	used experimentally	380 Copper T IUDs (n=15) resulted in pregnancy rates of 20, 71, 86 and 100% compared to 75, 75, 88 and 100% for controls for year 1-4 post-treatment, respectively	contraceptive efficacy only lasted 1 year	Killian et al. (2008) Wildl Res 35:103-115
	iUPOD	2 studies completed	self-assembling magnets form a triangle in the uterus; retention length was up to 5 months; requires that mares are not pregnant	contraceptive efficacy not tested	Gradil et al. 2019
			0% of the treated mares became pregnant over a 3 month (n=4) or 4 month (n=4) period; 5 of 8 mares had intra-uterine fluid build-up, but improved with estrus & ovulation and none of the mares had fluid build-up at the completion of the study; reversibility was observed within 30 days post-device retrieval	mares cycle but also experience prolonged diestrus; contraceptive efficacy was 100% for 3-4 months	Gradil et al. (submitted)