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Effect of parity number, year and season farrowing on reproductive performance in Large White pigs

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This study examines certain identifiable non-genetic sources of variation (parity number, year and season farrowing) for their effects on Large White sow litter performance traits, such as litter size, mortality and weight of piglets at birth and at weaning. The population used for the present study is from a pig farm managed by Tavriys'ki svyni, LLC, located in Skadovsky district (Kherson Oblast, Ukraine). Reproductive performance records on 280 Large White (LW) sows were used. A total of 633 litters were farrowed from January 2007 to July 2017. The litter records included information on the total number of piglets born (TNB), number of piglets born alive (NBA), number of stillborn piglets (NSB), frequency of stillborn piglets (FSB), average weight of piglets at birth (AWPB), litter size at weaning (NW), piglet pre-weaning mortality (PWM) and average weight of piglets at weaning (AWPW). To determine the effect of parity number, year and month farrowing on reproductive performance traits, the analysis of variance (ANOVA) was used.

Results obtained showed significant influence of parity number on most of the reproductive parameters studied, apart from AWPB, PWM and AWPW. The total litter size at birth was the lowest in primiparous sows and in cases second-parity sows, but significantly exceeded the overall average population estimation during the fourth-sixth parities farrowing. The least squares estimates of the mortality rate of piglets at birth were significantly lower than in second parity sows, however they significantly increased in sows at eighth parity. The year of the sow's farrowing had the most significant influence on the weight of piglets at birth and at weaning. Moreover, a clear upward trend can be noted in relation to the weight of piglets at birth, which is accompanied by a gradual increase of the corresponding least squares estimates during 2007-2015. Late summer and early autumn (August-October) are the seasons when the litter size traits in the LW sows consistently show the lowest values, indicating a 'seasonal infertility period'. Thus, all the analysis performed in the present work shows that in the LW sows, as in other pig breeds, the parity number, year and season farrowing influence the reproductive and developmental processes.

Key words: sows, the Large White breed, parity number, year and season farrowing, reproductive performance traits

Introduction

An analysis of the condition of animal husbandry in Ukraine in 1990-2015 showed that in order to overcome the crisis in the coming years, the total number of pigs must be increased from 6.7 to 22.0 million head, which will provide not only the competitiveness of the pig breeding industry, but also satisfy the demand of the population of Ukraine. During 2011-2019, the number of nursing sows of the Large White and Landrace breeds decreased by 2-3 times (Voitenko et al., 2019). Currently, these two breeds together make up to 85% of the commercial pig population (Kramarenko et al., 2018).

In current commercial pig breeding programs, great emphasis is placed on improving reproductive traits in sows. In general the breeding goal is to increase the number of piglets weaned per sow per year (Hanenberg et al., 2001). The improvement of litter size or sow productivity, however, is something of an enigma, as it is often difficult to identify and quantify the actual causes of variation (Kennedy & Moxley, 1978).

According to Patterson et al. (2010), sows are capable of raising an average of 30-40 piglets annually, hence the need to study the reproductive performance of sows under different environments. Litter size at birth and at weaning and average weight of piglets at birth and at weaning are among the primary parameters used to measure the reproductive performance of sows. These important reproductive traits could be influenced by season, parity, breed and nutrition (Bloemhof et al., 2008). Whereas the last two factors can be controlled, year/season farrowing and parity could be difficult to control because they directly affect the volume of production. It is therefore important to perform a detailed analysis on how these could impact performance (Hagan & Etim, 2019).

Seasonal and climatic influence on pig production had been reported in a number of studies in different countries. According to Leigh (1977), year farrowing effect was significant for the litter size, but parity and season farrowing effects were significant only for litter size at birth, which increased up to the fifth parity and then declined steadily in subsequent parities. In addition it had been noted that the effects of the season or of the farrowing month are controversial, in particular because of the variation in the housing condition of the animals (Legault et al., 1975).

Thus, this study examines certain identifiable non-genetic sources of variation (parity number, year and season farrowing) for their effects on Large White sow litter performance traits, such as litter size, mortality and weight of piglets at birth and at weaning.

Materials and methods

The population used for the present study is from a pig farm managed by Tavriys'ki svyni, LLC, located in Skadovsky district (Kherson Oblast, Ukraine). Reproductive performance records on 280 Large White (LW) sows were used. A total of 633 litters were farrowed from January 2007 to July 2017. The litter records included information on the total number of piglets born (TNB), number of piglets born alive (NBA), number of stillborn piglets (NSB), frequency of stillborn piglets (FSB), average weight of piglets at birth (AWPB), litter size at weaning (NW), piglet pre-weaning mortality (PWM) and average weight of piglets at weaning (AWPW). To determine the effect of parity number, year and month farrowing on reproductive performance traits, the analysis of variance (ANOVA) was used.

The following General Linear Model (GLM) model was used in order to determine the phenotypic variability of the reproductive performance traits:

$$Y_{ijkl} = \mu + P_i + FY_j + FM_k + e_{ijkl}, \quad (1)$$

where

Y_{ijkl} – is the value of the dependent variable; μ – the overall average; P_i – the fixed effect of i-th parity (i = 1, 2, ..., 10);

FY_j – the fixed effect of j-th farrowing year (j = 2007, 2008, ..., 2017); FM_k – the fixed effect of k-th farrowing month (k = January, February, ..., December); e_{ijkl} – the residual effect.

A significance level of 0.05 was used for all analyses. Data were tested using analysis of variance (ANOVA) with the GLM procedure of MINITAB Release 13.1 (MINITAB Inc. 2000).

Results

Table 1 shows the effect of parity number, farrowing year and month on the reproductive performance traits of the LW sows.

We refistered significant influence of parity number on most of the reproductive parameters studied, apart from AWPB, PWM and AWPW. Least squares estimates of the effects of parity number are in Table 2.

The total litter size at birth was the lowest in primiparous sows and in cases second-parity sows, but significantly exceeded the overall average population estimation during the fourth-sixth parities farrowing. However, the number of piglets born alive in younger parity sows (i.e., at first and second parity) did not significantly exceed the overall population estimation. The least squares estimates of the mortality rate of piglets at birth (i.e., the NSB and FSB) were significantly lower in second parity sows, however they significantly increased in sows at eighth parity.

Although the effect of parity number on piglet pre-weaning mortality was non-significant, in the LW sows studied the least squares estimates of litter size at weaning were significantly higher in sows at third-fourth parities, but significantly lower in sows at eighth parity.

In primiparous sows, the average weight of piglets at weaning was almost one kg less than in older parity sows.

Farrowing year

Obtained results showed significant influence of the farrowing year on most of the reproductive parameters studied, apart from PWM (Table 1). Least squares estimates of the effects of farrowing year are in Table 3. The least squares estimates of the total litter size at birth were significantly higher than the overall average population in sows farrowing in 2007, but in sows farrowing in 2013 and 2016, these estimates ranged from -0.996 to -1.033 piglets per litter.

In 2010 and 2012, the mortality rate of piglets at birth was the highest for the entire study period, resulting in a significant decrease in the least squares estimates of the number of piglets born alive. At the same time, the lowest estimates of this trait were noted in sows farrowing in 2013, and the highest in sows farrowing during in 2007-2008. The low least squares estimates of the litter size at weaning in 2010 and 2013 can be explained, on one hand, by an increase of the piglet pre-weaning mortality, and on the other hand, associated with the lowest estimates by the number of piglets born alive per litter in 2013.

The year of the sow's farrowing had the most significant influence on the weight of piglets at birth and at weaning (Table 1). Moreover, a clear upward trend can be noted in relation to the weight of piglets at birth, which is accompanied by a gradual increase of the corresponding least squares estimates during 2007-2015.

Table 1. Analyses of variance for the non-genetic factors (parity number, farrowing year and month) affecting litter performance traits of the LW sows

Traits	Parity number		Farrowing year		Farrowing month	
	F(9; 596)	*P*	*F*(10; 596)	*P*	*F*(11; 596)	*P*
TNB	3.75	< 0.001	2.98	0.001	0.87	ns
NBA	3.71	< 0.001	5.41	< 0.001	1.11	ns
NSB	2.88	0.002	2.84	0.002	0.60	ns
FSB	2.92	0.002	3.22	< 0.001	0.64	ns
AWPB	0.74	ns	31.62	< 0.001	1.04	ns
NW	2.23	0.019	4.98	< 0.001	1.45	ns
PWM	1.09	ns	1.54	ns	2.38	0.007
AWPW	1.79	ns	10.73	< 0.001	4.76	< 0.001

Parity number

As for the weight of piglets at weaning, the negative significant least squares estimates were noted in sows farrowing during 2008-2011, and the positive significant estimates were recorded in sows farrowing during in 2013, 2014 and 2016. On the other hand, sows that were farrowing in 2007 were characterized by heavier piglets at weaning, which exceeded the overall average by 1.678 kg.

Table 2. The least squares estimates and standard errors (*LSE ± SE*) of the effects of parity number on the LW sows litter performance traits

Parity number	Litter performance traits							
	TNB (no.)	NBA (no.)	NSB (no.)	FSB (%)	AWPB (kg)	NW (no.)	PWM (%)	AWPW (kg)
1	-0.834* ± 0.334	-0.504 ± 0.280	-0.330 ± 0.204	-2.061 ±1.457	-0.022 ± 0.024	0.074 ± 0.264	-3.059 ± 2.309	-0.977* ± 0.401
2	-0.764* ± 0.292	-0.244 ± 0.246	-0.520* ± 0.178	-3.391* ± 1.272	-0.003 ± 0.021	0.060 ± 0.231	-2.807 ± 2.016	-0.242 ± 0.350
3	-0.036 ± 0.280	0.286 ± 0.235	-0.322 ± 0.171	-2.318 ± 1.223	0.001 ± 0.020	0.487* ± 0.222	-2.022 ± 1.938	0.076 ± 0.337
4	0.613* ± 0.295	0.844* ± 0.247	-0.231 ± 0.180	-2.367 ± 1.287	-0.007 ± 0.021	0.673* ± 0.233	0.317 ± 2.039	-0.332 ± 0.354
5	0.808* ± 0.300	0.633* ± 0.251	0.175 ± 0.183	0.870 ± 1.308	0.026 ± 0.022	0.352 ± 0.237	1.344 ± 2.072	-0.008 ± 0.360
6	0.920* ± 0.315	0.967* ± 0.264	-0.048 ± 0.193	-0.319 ± 1.375	-0.013 ± 0.023	0.460 ± 0.249	3.044 ± 2.179	-0.447 ± 0.379
7	0.051 ± 0.350	0.108 ± 0.294	-0.057 ± 0.214	-0.250 ± 1.527	0.018 ± 0.025	-0.087 ± 0.277	1.737 ± 2.420	-0.510 ± 0.421
8	0.519 ± 0.425	-0.439 ± 0.356	0.958* ± 0.260	7.310* ± 1.853	-0.053 ± 0.031	-0.884* ± 0.336	5.088 ± 2.937	-0.305 ± 0.510
9	0.089 ± 0.646	-0.143 ± 0.542	0.232 ± 0.395	0.911 ± 2.821	0.006 ± 0.047	0.054 ± 0.511	-2.183 ± 4.469	-1.005 ± 0.777
10	0	0	0	0	0	0	0	0

Here and then values marked with * were significantly different from 0 ($P < 0.05$).

Table 3. The least squares estimates and standard errors (*LSE ± SE*) of the effects of farrowing year on the LW sows litter performance traits

Farrowing year	Litter performance traits							
	TNB (no.)	NBA (no.)	NSB (no.)	FSB (%)	AWPB (kg)	NW (no.)	PWM (%)	AWPW (kg)
2007	0.841* ± 0.325	0.748* ± 0.273	0.093 ± 0.199	0.024 ± 1.419	-0.245* ± 0.024	0.227 ± 0.257	3.138 ± 2.249	1.678* ± 0.391
2008	0.447 ± 0.333	0.636* ± 0.280	-0.189 ± 0.204	-1.480 ± 1.455	-0.236* ± 0.024	0.096 ± 0.264	3.433 ± 2.305	-2.832* ± 0.401
2009	0.273 ± 0.347	0.099 ± 0.291	0.175 ± 0.212	1.089 ± 1.515	-0.172* ± 0.025	-0.173 ± 0.275	0.929 ± 2.400	-1.404* ± 0.417
2010	-0.480 ± 0.308	-0.853* ± 0.258	0.373* ± 0.188	3.685* ± 1.344	0.073* ± 0.022	-1.157* ± 0.244	4.395* ± 2.129	-0.951* ± 0.370
2011	0.097 ± 0.293	-0.237 ± 0.245	0.334 ± 0.179	2.049 ± 1.277	0.070* ± 0.021	-0.423 ± 0.231	2.589 ± 2.023	-1.237* ± 0.352
2012	0.101 ± 0.286	-0.556* ± 0.240	0.657* ± 0.175	4.481* ± 1.249	0.071* ± 0.021	-0.420 ± 0.227	0.054 ± 1.980	-0.318 ± 0.344
2013	-0.996* ± 0.276	-1.131* ± 0.236	0.135 ± 0.169	2.312 ± 1.205	0.073* ± 0.020	-0.627* ± 0.219	-2.438 ± 1.910	0.715* ± 0.332
2014	0.038 ± 0.318	0.040 ± 0.267	-0.002 ± 0.195	-0.006 ± 1.389	0.096* ± 0.023	0.481 ± 0.252	-3.342 ± 2.201	0.791* ± 0.383
2015	-0.262 ± 0.363	0.121 ± 0.305	-0.383 ± 0.222	-2.839 ± 1.585	0.123* ± 0.026	0.446 ± 0.287	-2.872 ± 2.511	-0.556 ± 0.437
2016	-1.033* ± 0.478	-0.493 ± 0.401	-0.538 ± 0.292	-3.759 ± 2.086	0.065 ± 0.035	-0.250 ± 0.378	-0.450 ± 3.306	1.152* ± 0.575
2017	0	0	0	0	0	0	0	0

Farrowing month

Finally, we found that the effects of farrowing month on most of the litter performance traits was non-significant (P > 0.05), apart from PWM and AWPW (Table 1). Least squares estimates of the effects of farrowing month are in Table 4.

The least squares estimate of the number of piglets at weaning, which was significantly lower than the overall average estimate, was noted in sows farrowing in September. Thus, late summer and early autumn (August-October) are the seasons when the litter size traits in the LW sows consistently show the lowest values, indicating a seasonal infertility period' (Peltoniemi et al., 1999).

On the other hand, sows with farrowing in August were characterized by lower piglet pre-weaning mortality. Sows farrowing in June and August were characterized by heavier piglets at weaning, which exceeded the overall population average by 1.666 and 1.351 kg, respectively. Whereas sows farrowing in February had lighter piglets in the litter at weaning.

Discussion

Parity number

The number of parity which is associated with the physiological status of the animals (growth, development of the reproductive system, body condition, etc.), are the main independent factors determining the reproductive functions of the sows (Schwarz & Kopyra, 2006), with proven tendencies to increase the reproductive parameters in sows with third-fifth parities. This factor directly affect animal reproductive performance, hence the analysis of their effect is of a great importance for commercial herd production (Dimitrov et al., 2018). The general effect of parity on litter size might be related to ovulation rate (Tantasuparuk et al., 2000).

Table 4. The least squares estimates and standard errors (*LSE ± SE*) of the effects of farrowing month on the LW sows litter performance traits

Farrowing month	Litter performance traits							
	TNB (no.)	NBA (no.)	NSB (no.)	FSB (%)	AWPB (kg)	NW (no.)	PWM (%)	AWPW (kg)
Jan	-0.007 ± 0.308	0.207 ± 0.258	-0.213 ± 0.188	-1.916 ± 1.345	-0.002 ± 0.022	-0.107 ± 0.244	2.950 ± 2.131	0.173 ± 0.370
Feb	0.489 ± 0.315	0.471 ± 0.264	0.018 ± 0.192	-0.316 ± 1.373	-0.034 ± 0.023	-0.074 ± 0.249	3.558 ± 2.176	-0.787* ± 0.378
Mar	0.049 ± 0.339	0.116 ± 0.284	-0.067 ± 0.207	-0.742 ± 1.479	0.010 ± 0.025	-0.100 ± 0.268	2.300 ± 2.343	-0.396 ± 0.407
Apr	0.250 ± 0.347	0.137 ± 0.291	0.114 ± 0.212	1.131 ± 1.516	0.009 ± 0.025	-0.140 ± 0.275	2.836 ± 2.402	0.368 ± 0.418
May	-0.478 ± 0.322	-0.231 ± 0.270	-0.247 ± 0.197	-0.813 ± 1.406	-0.029 ± 0.023	-0.016 ± 0.255	-1.845 ± 2.228	0.720 ± 0.387
Jun	0.383 ± 0.326	0.320 ± 0.274	0.063 ± 0.200	0.128 ± 1.425	0.039 ± 0.024	0.438 ± 0.258	-2.060 ± 2.257	1.666* ± 0.392
Jul	0.105 ± 0.308	-0.067 ± 0.258	0.172 ± 0.188	1.157 ± 1.345	0.024 ± 0.022	0.397 ± 0.244	-3.908 ± 2.131	-0.112 ± 0.370
Aug	-0.150 ± 0.317	-0.360 ± 0.266	0.210 ± 0.194	1.702 ± 1.383	0.028 ± 0.023	0.180 ± 0.251	-4.738* ± 2.191	1.351* ± 0.381
Sep	-0.287 ± 0.325	-0.290 ± 0.273	0.003 ± 0.199	0.462 ± 1.419	-0.016 ± 0.024	-0.621* ± 0.257	4.125 ± 2.248	-0.371 ± 0.391
Oct	-0.568 ± 0.380	-0.586 ± 0.319	0.018 ± 0.232	0.700 ± 1.659	-0.044 ± 0.028	-0.020 ± 0.301	-4.355 ± 2.629	-0.448 ± 0.457
Nov	-0.036 ± 0.320	0.186 ± 0.268	-0.222 ± 0.195	-1.892 ± 1.395	0.011 ± 0.023	0.453 ± 0.253	-3.449 ± 2.210	-0.602 ± 0.384
Dec	0	0	0	0	0	0	0	0

Litter size in the present study showed an increase with parity number, reaching a plateau, and then declining. This is largely in accordance with earlier studies (Koketsu & Dial, 1997; Tantasuparuk et al., 2000; Tummaruk et al., 2000). According to Yen et al. (1987), the performance litter traits were better for sows of the Yorkshire, Duroc, Chester White, Hampshire, Spotted and Landrace breeds and crossbreds in parities 3-6 than for gilts or other parities. A curvilinear relationship between litter size and parity (with the largest litters from sows in parities three through ten) had been reported in a target population of Ontario swine farms (Dewey et al., 1995).

For farrowing performance in the Kagoshima Berkshire gilts and sows (Sasaki et al., 2014), the highest numbers of total piglets born and piglets born alive were found in sows with parities 5 and 6 and with parities 3-6, respectively. Regarding weaning and mating performance, sows with parity 2 had the lowest pre-weaning mortality. In our study, the highest numbers of piglets at weaning were found in sows with parities 3 and 4 (Table 2).

In addition, the effect of parity 1 litter size on litter size of subsequent parities 3 through 7 was significant (Clark & Leman, 1987). This correlation allowed us to develop the method of individual forecasting of sow reproductive performance on the basis of a non-linear canonical model of a random sequence (Atamanyuk et al., 2019).

In tropical climates sows in parity seven and beyond had smaller litters, with lower birth weights and growth rates to weaning, thus justifying the practice of culling sows after the sixth parity (Mungate et al., 1999). A two-way interaction between parity number and farrowing season was found in sows (Koketsu & Dial, 1998). Parity 1 sows produced lighter piglet weights than any other parity group during any other season. Average weights of weaned piglets farrowed during the summer in all parity groups were lighter than those during the autumn.

As in the present study, the number of stillborn piglets was low in parity 2 and 3 but high in parity 1 and after parity 4 in purebred Landrace and Yorkshire sows in Thailand (Tantasuparuk et al., 2000; Imboonta et al., 2007). As Canario et al. (2006) had stated previously, the probability of stillbirth was greater for lighter piglets, for male piglets, and for piglets from small or very large litters. Additionally, this probability increased with sow parity number and with farrowing duration. On average, number of stillborn piglets increased between the second and the fifth parity (Leenhouwers et al., 1999).

Farrowing year/season/month

In the presented study we report the significant influence of farrowing year on most of the reproductive parameters studied in the LW sows, apart from PWM (Tables 1 and 3). Although in the earlier paper of Kennedy & Moxley (1978), it had been noted that year of farrowing effects were not significant for any trait of the reproductive performance in the Yorkshire, Landrace and Lacombe sows.

Seasonal changes in reproductive performance of sows were described in different climates. The primary environmental factors that influence reproductive indicators are photoperiod, temperature, and humidity, but temperature and humidity seem more significant

under tropical conditions and photoperiod is the most important in temperate climates (Love et al., 1993; Prunier et al., 1997; Tantasuparuk et al., 2000).

Although the season of farrowing did not significantly affect any trait, the least squares estimates of seasonal effects suggested that litters were largest in January to April (Kennedy & Moxley (1978). In Spanish Iberian pigs litters born in winter were larger than in any other season of the year but their survival rate was the lowest (Dobao et al., 1983). Analogically, in our study, it was noted that the highest litter size at birth was observed for sows that were farrowing in February (Table 4).

Based on data from three purebred sow herds located in the central region of Thailand, Tantasuparuk et al. (2000) reported that poor litter sizes (NTB and NBA) were found during the rainy season (July-October), and the largest litter sizes were found during the hot season (March-June).

Interbreed differences can influence the received relationships. In the tropical climate of Thailand, the litter sizes in the Landrace sows were low during the second half of the year and were lowest in August, whereas the Yorkshire litter sizes were lowest during July through September (Tantasuparuk et al., 2000). Wherein winter farrowings corresponded to late summer and early autumn matings. Sows mated in the autumn and poorest by summer-mated sows (Schwarz et al., 2009) obtained best results for the reproductive performance of the Polish Large White. According to Knecht & Duziński (2014), statistically, the lowest number of piglets born alive and weaned in the Polish Large White × Polish Landrace was observed as a result of summer month insemination (July, August, September) compared to the winter months (February, March).

On the other hand, the seasonal variation of the reproductive performance of female swine was analyzed by use of a database that included farrowing records from 42 commercial swine herds, and it had been noted that sows mated in November through January had a greater total number of piglets born per litter, more piglets born alive per litter, and greater litter birth weights than sows mated in June through August (Xue et al., 1994).

Moreover, the effects of season varied across parities. Analyzing genetic parameters for reproduction and production traits of the Landrace sows in Thailand, it had been noted that primiparous sows farrowing between July and October had the lowest NTB and primiparous and multiparous sows farrowing in September/October had the lowest NSB (Imboonta et al., 2007).

Primiparous sows had the greatest seasonal variability in weaning-to-estrus interval, whereas multiparous sows had the greatest seasonal variability in total number of piglets born per litter and piglets born alive per litter (Xue et al., 1994). They hypothesised that primiparous sows might have a different physiological response to season compared with multiparous sows.

In hot climates, the effect of environmental factors on pre-weaning performance traits was studied by Mungate et al. (1999) and sow performance in terms of number born alive was higher if sows were farrowed in the summer months of October to April than at any other time of the year. The heaviest piglets were also born during the same period.

In Finnish pure- and crossbred sows, a consistent seasonal effect was observed in three-week litter weight across the parities: the litter weight was at the highest in February-March with two dips in June and November. The seasonal variation seen in litter weight in the present data was between two and three kg, depending on the parity (Peltoniemi et al., 1999). On other hand, according to Koketsu & Dial (1997), in southern Minnesota (USA) sows farrowing in summer produced the lightest litter weight at weaning.

Conclusion

Results obtained showed significant influence of parity number on most of the reproductive parameters studied, apart from AWPB, PWM and AWPW. The total litter size at birth was the lowest in primiparous sows and in cases second-parity sows, but significantly exceeded the overall average population estimation during the fourth-sixth parities farrowing. The least squares estimates of the mortality rate of piglets at birth (i.e., the NSB and FSB indicators) were significantly lower than in second parity sows, however they significantly increased in sows at eighth parity. The year of the sow's farrowing had the most significant influence on the weight of piglets at birth and at weaning. Moreover, a clear upward trend can be noted in relation to the weight of piglets at birth, which is accompanied by a gradual increase of the corresponding least squares estimates during 2007 through 2015. Late summer and early autumn (August-October) are the seasons when the litter size traits in the LW sows consistently show the lowest values, indicating a 'seasonal infertility period'. Thus, all the analysis performed in the present work shows that in the LW sows, as in other pig breeds, the parity number, year and season farrowing influence the reproductive and developmental processes.

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