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Different rates of development in two geographical races of Asellus aquaticus, their genetic determination and adaptive significance

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SEZIONE III

(Botanica, zoologia, fisiologia e patologia)

Ecologia. — *Different rates of development in two geographical races of* Asellus aquaticus, *their genetic determination and adaptive significance* (*). Nota di ELISA ANNA FANO, FLORA VALENTINO e GIOVANNA VITAGLIANO TADINI, presentata (**) dal Socio G. MONTALENTI.

RIASSUNTO. — È stato studiato il comportamento degli ibridi di F_1 e F_2 di due razze geografiche di *Asellus aquaticus* (L.) provenienti rispettivamente dall'Olanda e dal Sud Italia. Il carattere seguito è la velocità di sviluppo, significativamente diversa nelle due razze parentali; la determinazione è poligenica come è dimostrato dalla segregazione della F_2.

È stata dimostrata l'importanza del tipo di determinazione genetica che limitando la plasticità del carattere fissa i « tempi » di sviluppo delle rispettive razze consentendo una diversa sincronizzazione fra questa importante fase del ciclo biologico ed i parametri stagionali dei due ambienti.

We have studied the time necessary for sex differentiation in the hybrid F_1 and F_2 of two geographical races of *Asellus aquaticus* (L.) (Crust. Isop.). The parent races are known [1, 2] to differ significantly in the number of days necessary to reach sex differentiation. One of the two parent races was from the North (Dutch canals near The Hague) and the other from the South (canals of the Sarno river, Naples).

In the text the two races (northern and southern) will be termed n.r. and s.r.

Our aim was to establish the part played by the genetic component in determining this character which is of great ecological-adaptive importance. In fact it represents a phase of the biological cycle which occurs in the span of only two or three seasons respectively at two very distant latitudes.

Those individuals which had acquired distinguishable external sex characters (Ist and IInd pleopods and oostegites in the females) which are different and/or absent in the undifferentiated individuals [3, 4] were considered sexually differentiated.

The experiment was carried out exclusively in the spring-summer half of the year, since we have already shown that the rate of development in the n.r. is photoperiod-dependent. Besides, in autumn the northern race goes into reproductive stasis and stays there until the next spring with an almost

(*) Study carried out at the Centro di Genetica Evoluzionistica of the C.N.R. headed by prof. G. Montalenti.

(**) Nella seduta del 13 marzo 1976.

total absence of offspring [5, 6]. The very limited offspring, in this period, are without exception killed by temperatures below 7 °C.

The F_2 of all the experiments was born of the F_1 couples belonging to the modal classes.

The populations were reared in thermostatic rooms (18 °C) in glass crystallization vessels and given filtered well water and plant detritus in standard conditions. The photoperiod was the natural one perceived through large glass windows.

Results

In Table I the absolute numbers of differentiated individuals [1] are given for all populations as a function of time. In the first line the intervals of time considered [2] are reported.

The value for the modal classes are shown in bold type.

TABLE I

Rates of development in two geographical races of Asellus aquaticus

Populations	No. of days necessary for sex differentiation							
	1–20	21–40	41–60	61–80	81–100	101–120	121–140	141–160
Northern parent . .	6	**278**	143	32	8			
Northern F_1 . . .	12	**128**	33	16				
Northern F_2 . . .	9	**124**	33	24	15			
Southern parent . .		32	197	241	**761**	82	27	26
Southern F_1 . . .		49	78	142	**195**	117	32	
Southern F_2 . . .		24	25	35	**121**	58	15	
Hybrid F_1		116	**257**	51	15			
Hybrid F_2	9	**97**	81	49	8	4		

Table II shows the values of the mode and the mean for each population and the percent values of mortality.

As can be seen the two races differ markedly in the parent generation, in F_1 and F_2:

1) in the number of days necessary for most individuals to be sexually differentiated;

(1) The number of differentiated individuals and the intervals of time were considered "phenotypical characters". The genotype is deduced from the behaviour of the F_1 and the F_2.

(2) In the 1st class differentiation takes place no earlier than the 19th-20th day.

2) for all individuals to reach sexual differentiation;

3) in the different scattering about the mean and the mode.

For the n.r. 5 classes (two of which fundamental) are present since all individuals are differentiated by the 100 th day after leaving the " marsupial pouch ".

7 classes (of which 4 fundamental) are present for the s.r. No individual develops before the 25th day and a great number of individuals take much longer than ninety days, sometimes even up to 160 days.

TABLE II

Analysis of the rates of development in two geographical races of Asellus aquaticus

Populations	Total No. examined	Total No. of survivors	% deaths	Mode (days)	Mean (days)
Northern parent . . .	510	467	8.43	39	43.10
Northern F_1	210	189	10.00	39	38.43
Northern F_2	240	205	14.58	23	44.39
Southern parent . . .	1396	1366	2.14	90	82.49
Southern F_1	652	613	5.98	98	81.63
Southern F_2	305	278	8.85	81	81.00
Hybrid F_1	484	439	9.29	48	48.09
Hybrid F_2	279	248	11.11	30	46.45

The two mean values are so different from each other that the " character " considered (time necessary for sex differentiation) is certainly due to a racial genetic component. This is shown by the fact that the generations F_1 and F_2 of the n. and s. races, raised in identical environmental conditions, maintain the characteristic differences of the parental race. The number of classes present in all generations represents the typical scattering about the mean of a polygenic determinism, the standardization of rearing conditions being taken into account.

The hybrid population between the two races, F_1, has the average number of individuals in intermediate positions, even if displaced towards the n.r. The number of classes is very limited (only 4, two of which widely represented).

The hybrid population F_2 has a broad variability (6 classes) and some segregating individuals similar to the n.r. (which develop before the 20th day) and others similar to the s.r. (before the 120 th day) reappear.

Discussion and Conclusions

An examination of the whole of the data obtained shows that:

1) the "character" studied—time to reach sex differentiation—in two races of *Asellus aquaticus* of Northern and Southern Europe is genetically determined. In fact the "times" of the parent generations—significantly different—remain so in the F_1 and F_2 of the respective races and are intermediate in the F_1 hybrid while the F_2 hybrid markedly segregates.

The type of determination is probably polygenic, in fact the variation about the mean value is very broad (particularly in the s.r. and in the F_2 hybrid). The behaviour of the F_1 and the F_2 hybrids leads us to suppose that the northern and southern races are respectively dominant homozygous and recessive homozygous for some gene pairs and that the n.r. is homozygous (dominant) for other gene pairs which, in the southern race, could be in a heterozygous condition. The latter hypothesis would explain *a*) the greater variability of the s.r. and *b*) the displacement of the F_1 and F_2 hybrid towards the modal value of the n.r.

2) The two races differ substantially in the range of variability, in the modal class and in the total absence of individuals developing with the extreme times present in the other race, but in both races are present—with low frequency—individuals developing with times characteristic of the main classes of the other race.

We have shown, that is, that in the northern race numerous genotypes were selected for a quick attainment of sexual development, while in the southern race genotypes which were much slower developing were selected with a very high frequency.

As we have already mentioned, we believe that this difference has a very high ecological-adaptive significance. In fact the northern race is characterized by the suspension of births in the autumn-winter months, while the southern race reproduces all year round. It seems to us that it is really important that in a population (like the northern one) which 'starts' sexual activity again in the month of March—and which is therefore numerically reduced to only the surviving adults—genotypes were selected which were capable of developing in only 21–40 and/or 41–60 days so that: *a*) the new generation will very quickly substitute the adult one and *b*) all individuals have the possibility of reproducing at least once before the reproductive stasis which begins in the month of October. Selection against the slow developers has an equally important adaptive significance. In fact, if the offspring of June, July and August took (like the southern ones) 5 months to reach sexual maturity this would be attained in vain since reproductive stasis would already be under way. While being genetically determined for quick development they can take the September generation up to such a high number that the probability that a fair number of individuals will survive until the next spring is very high.

In the southern race, which reproduces all year round, there was instead an accentuated variability (seven classes, four of which very numerous). This variability acquires ecological-adaptive significance if we remember that the southern biotope (wells and canals poorly connected with the river) undergoes important variations of almost all the environmental parameters after the great summer dryness and the heavy winter rains, with resultant splitting up into small reproductive communities (in the three dry months). Therefore the dimensions of the genetic pool dilate and contract according to the possibility of outbreeding. The great variability in time of attainment of sexual maturity is of doubtless adaptive value, in fact in this way many births are certainly postponed until the wet season thus preventing overcrowding. The fast developing genotypes ensure this period a minimum of births. Outbreeding is automatically guaranteed in the splitting up period by the variability of the character and after the rains by the remixing of all the reproductive communities.

In conclusion, we think that we have shown that:

1) the two races certainly belong to the same species, given the low mortality of the hybrids of F_1 and F_2;

2) the character genetically examined (rate of development) is a racial character with regard to *a*) the mean, the mode, the range of variability and *b*) the lack of individuals representing the extreme classes typical of every race, but with many classes superimposed;

3) the character has a genetical polygenic determination; it is probably dominant for numerous pairs of genes in the northern race, homozygous recessive for some pairs and heterozygous for others in the southern one;

4) the selection of high frequencies of " fast developing " genotypes permits immediate repopulation in the brief reproductive period (spring-summer) of the northern race;

5) the accentuated variability permits the southern race, which reproduces all year round, to stand up to the striking variations which occur in its environment;

6) it is of particular importance that the genetic determination restrict the limits of plasticity of a character playing a primary role in the adaptation of the biological cycle to the environment.

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