COMPARISON OF OVARIAN SIZE AND NUMBER OF OVARIOLES BETWEEN THE WORKERS OF JAPANESE AND EUROPEAN HONEYBEES (Studies on the Japanese honeybee, *Apis indica cerana* Fabricius. I)[1]

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The Japanese honeybee, *Apis indica cerana* Fabricius is distinguished from the European honeybee, *Apis mellifera* Linné by a number of morpho-ethological characters. Some of these peculiarities were already descrided by Tokuda '24 and Okada, Sakai and Hasegawa '56. There exist, however, still other distinctive features which will be reported subsequently in the present serial publications. As the first attempt, we should like to describe some anatomical peculiarities in the ovarian structure of this species in comparison with those of her European cousin.

Before going further, a brief remark may be necessary on the reason by which we have adopted for our material the scientific mane entitled above. Up to present, there are two classificatory systems in the taxonomy of honeybees, which differ, after our opinion, essentially only on the treatment of generic and infrageneric ranks. The most authors admit four species in the genus *Apis* Linné, namely, *A. mellifera* Linné (=*A. mellifica* Linné), *A. indica* Fabricius, *A. florea* Fabricius and *A. dorsata* Fabricius. Many of them are, however, inclined to the opinion that *A. indica* might be rather a subspecies of *A. mellifera* (Ruttner & Mackensen '52; Muttoo '51; Butler '54). On the other hand, there is another viewpoint which admits three genera, *Magapis*, *Micrapis* and *Apis* in the Tribe Apidini and considers *Apis indica* as a distinct species (Skorikov '29; Maa '53). Moreover, Maa errected a new subgenus *Sigmatapis* for the *indica*-group and separated the Japanese (or Far-Eastern) as a distinct species, *Apis cerana* Fabr. (=*A. sinensis* Smith=*A. japonica* Radoszkowski) from *Apis indica*. At present, we are not well qualified for the honeybee taxonomy to judge whether *Apis indica* is a mere subspecies of *A. mellifera* or *subgenerically* distinct from the latter. We will use the name *Apis indica* throughout our serial work only to mention a doubtless fact, that the morpho-ethological differences between *Apis indica*-group and *A. mellifera* are far greater than those found among any of various subspecies or races of the latter species. The adoption of the subspecific name *Apis indica cerana* is also not based upon the conclusion that the Japanese bee is a subspecies of *Apis indica*, but only upon two facts: 1, the Japanese bee belongs clearly to the *indica*-group and 2, we deal with, for the time being, only with

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Japanese material but not with all the representatives of *indica*-group or *Sigmatapis* of Maa.

Already Tokuda mentioned an interestnig nature of the Japanese honeybee with respect to the appearance of laying workers. When dequeened either artificially or accidentally, *Apis indica cerana* shows, in the majoritiy of cases, no tendency to construct emergency queen cells in order to rear their next queen, but produces numerous laying workers during a relatively short interval. This character was also repeatedly observed by the senior author in the course of his studies with this bee and partly reported in the previous papers (Sakagami '54, in preparation). The occurrence of actual or potential laying workers is relatively rare in queenright colonies of *Apis mellifera* except immediately before the swarming (Tuenin '26). In *Apis indica cerana*, however, there exist occasionally actual or potential laying workers in colonies headed by a normal fertilized queen. One example may suffice to show such a tendency.

The colony observed was transported from Yamaguchi, Southern Japan and had arrived on IV 22 '55 to our laboratory in Sapporo. Since the next day, i. e. IV 23, 20 workers were randomly caught from the hive about every three days. Their ovaries were examined under the binocular microscope and classified into three stages according the degree of development (O: normal = rudimentary, I: commencement of swelling and constriction, II: with distinct ova). As seen in Table 1, one individual already showed on IV 23 the commencement of ovarian constriction. The developed ovaries were found again on V 2 in 9 individuals, namely, about half of examined specimens. Thereafter certain workers were always observed whose ovaries more or less developed until V 17, nevertheless no swarm tendency was noticed and the queen was seen in engaging actively in her sole task, oviposition, throughout the period observed.

Table 1. Appearance of ovary-developed workers in a queenright colony of *Apis indica cerana*.

Date examined		IV 23	26	28	29	V 2	5	8	11	14	17	VI 2
No. of ovaries belonging to various stages	O	19	20	20	20	11	9	10	15	19	18	20
	I					7	9	4	3	1	2	
	II					2	2	6	2			

In parallel with such a functional peculiarity, the ovaries of *Apis indica cerana* workers are remarkable in their conspicuous size if being compared to those of *Apis mellifera*. This is noticed already when the ovaries of these two species are examined side by side. The completely atrophied ovaries of *Apis mellifera* workers are almost thread-like. Ovarioles are so compactly attached to each other that, without a little experience, it is by no means easy to separate each one. On the other hand, the ovaries of *Apis indica cerana* workers, naturally also being rudi-

mentary, much more swollen than in those of *Apis mellifera.* Hence it is relatively easy to extract them from the abdomen and to separate each ovariole.

To obtain a quantitative estimate of this difference, about 100 workers were collected from hives of both species,* in the summer of 1953 (Colonies M_2 and C_3 cf. Table 3) and the maximal width of their ovaries was measured by the ocular micrometer. Table 2 tells clearly that there is no significant lateral asymmetry of the width measured in each species but a highly significant difference between two species.

Table 2. Maximal width of each ovary in *Apis mellifera* and *Apis indica cerana.*

	Apis mellifera		*Apis indica cerana*	
	left	*right*	*left*	*right*
Number of individuals examined	100	100	100	100
Mean value (mm)	0.112±0.00588	0.110±0.00608	0.451±0.0197	0.433±0.0199
Standard deviation (mm)	0.0588	0.0608	0.197	0.197
t-value	0.213		0.687	
	22,786			

To demonstrate this difference in another way, the ovaries of both species were illustrated in Fig. 1 with the same magnification (1955, Colonies M_1 and C_2). In each species, a number of workers were collected at their emergence, 10 of these young bees were immediately sacrificed for drawing (Fig. 1, B, C,) then other 10 bees were marked with colour-paint and released again in the hives, to be recaptured after 10 days for drawing (Fig. 1, D, E). The figures of these four series show no sign of ovary development in the course of adult life but a clear difference in the size of ovaries between two species. The commencement of ovary development was found in one *Apis indica cerana* worker of 10 days old (E, No. 1), nevertheless in both species all the samples were taken from queenright colonies.

Corresponiding to the size difference of ovaries, the number of ovarioles differs significantly between two species. This was studied in five *Apis indica cerana* and three *Apis mellifera* colonies. From the data presented in Table 3, the following results can be recognized:

1. With respect to the number of ovarioles, no significant left-right difference was found in all the colonies studied, either in mean value or in variance. Hence, the means of the both sides were averaged and the further comparison was executed among these averaged means of each colony.

* All the studied colonies of *A. mellifera* belong to the Italian, *Apis mellifera ligustica*, with a slight mixture of various black races, as in the majority of colonies kept in Japan.

Fig. 1. A. An example of well-developed ovaries in a laying worker of *Apis indica cerana*.
B. C. Ovaries of ten workers at emergence.
D. E. Ditto at 10 days old after emergence.
(B. D. *Apis mellifera ligustica*, C. E. *Apis indica cerana*)

2. There is a highly significant difference in ovariole number between the two species ($t=20.01$).

3. On the intra-specific variation in *Apis mellifera* colonies, both the means and variances show a highly significant difference in the comparisons M_1-M_2, and M_1-M_3 but not in M_2-M_3.

4. On the intra-specific variation in *Apis indica cerana* colonies, the means differ not significantly in C_2-C_3, C_2-C_4, C_3-C_4, but highly significantly in other paired comparisons. The difference of variances is not significant in C_3-C_4, significant in C_2-C_3 and highly significant in other combinations.

The number of studied colonies is as yet too small to give a reasonable explanation about the causes which have brought the intra-specific variation mentioned above, except in the case of colonies C_2 and C_4 which were obtained from the same locality. Much more quantitiative analysis with various local populatons may be desired before discussing the intra-specific variation of the ovariole number in both species.

On the other hand, the interspecific difference was established very clearly. The mean value in *Apis mellifera*, 3.64 ± 0.123, was obtained only based upon three colonies, but fairly coinsides with values reported by Hess ('42, 1-21, Mode=4), Haydak ('51, Mean=3.64-4.32), Komarov ('35, 2-24, 9.94 ± 0.11, in both ovaries combined), and differs distinctly with the higher value in *Apis indica cerana*, 7.77 ±0.107. This difference in the number of ovariole causes mainly the difference of ovarian size described above. If this structural difference between both species was considered together with the functional difference in the development of laying workers, it seems to be possible to assume that the worker bees of *Apis indica cerana* possesses a higher potential in functionning as normal females than those of *Apis mellifera*.

In this connection, it may be allowed to add here some peculiarities in the

Table 3. Number of ovarioles in *Apis mellifera* and *Apis indica cerana*.

Colony	Locality	Date	No of individuals determined	Side of ovarioles[1]	Mean	Min.	Mode	Max.	Standard deviation
C_1	Nishino-miya	III '57	46	L	6.26	3	5	13	2.03
			46	R	5.87	3	5	9	1.47
			92	Total	6.07				1.79
C_2	Yamaguchi	VI-IX '55	244	L	7.95	3	7	24	2.84
			250	R	8.10	3	6-7	30	3.35
			494	Total	8.03				3.10
C_3	Shiga	VIII '53	95	L	8.39	3	6	20	3.53
			100	R	7.94	3	5	30	3.70
			195	Total	8.16				3.62
C_4	Yamaguchi	III '57	18	L	8 06	5	6	16	2.69
			18	R	7.94	5	6-8	14	2.46
			36	Total	8.16				2.54
C_5	Shikoku	III '57	31	L	7.00	5	7	12	1.14
			31	R	6.71	4	6	10	1.37
			62	Total	6.85				1.39
M_1	Sapporo	VI-IX '55	100	L	4.03	1	3	26	2.95
			163	R	4.11	1	3	22	3.24
			263	Total	4.08				3.14
M_2	Sapporo	VIII '53	71	L	3.00	1	3	7	1.05
			70	R	3.14	1	3	12	1.51
			141	Total	3.07				1.29
M_3	Sapporo	III '57	36	L	3.36	1	2-3	10	0.96
			36	R	3.03	1	3	8	1.40
			72	Total	3.19				1.21
Ct[2]			434	L	7.80	3	6	24	2.97
			445	R	7.69	3	6	30	3.09
			879	Total	7.77				3.07
Mt[3]			207	L	3.46	1	3	26	2.68
			267	R	3.71	1	3	22	2.46
			474	Total	3.64				2.52

1) L and R are left and right respectively.
2) Total number of ovarioles in *Apis indica cerana*.
3) Total number of ovarioles in *Apis mellifera*.

ovary development of *Apis indica cerana*. Although not yet quantitatively confirmed, in *Apis indica cerana*, it is relatively rare to found the laying workers in which only the ovary of one side developed, which is often discovered in the case of *Apis mellifera*. Moreover, the development of each ovariole varies in *Apis indica cerana* not so markedly in each other than in *Apis mellifera*, whose laying workers

have often deformedly developed ovaries due to the unevenness in the development of each ovariole. Consequently, a well developed ovary consisted of numerous ovarioles in *Apis indica cerana* approaches often to the appearance characteristic to the huge ovary of normal queen (For example, Fig. 1, A, left ovary with 18, right with 9 ovarioles).

It may be too premature to discuss here whether such the morpho-functional properties are only characteristic to *Apis indica cerana*, or common throughout all the representatives of *indica*-group. But it is interesting to cite here the observation made by Millen '42. After this author, both the Hill and Plain varieties of *Apis indica* show in India a tendency to produce the laying workers relatively easily, in spite of the presence of normal queen. Moreover, Muttoo '56 mentioned recently the lower laying efficiency of *Apis indica* queens in India which deposit seldom more than 500–700/day in contrast to the rate of more than 2000/day in *Apis mellifera*. There are as yet no detailed records on the laying efficiency of the Japanese bee, but it is well known that the colony size of this bee usually not reaches the level which her European cousin maintains. Therefore, it may be not always unreasonable to suppose that the caste-development of *Apis indica* group is not so well differenciated as in *Apis mellifera*, though the correctiveness of this assumption must be tested through a series of further investigations.

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Summary

The Japanese honey bee, *Apis indica cerana* Fabr. has a tendency to produce the laying workers relatively. In parallel with this functional peculiarity, it was confirmed that the ovaries of this species are much larger and their ovarioles are more numerous than in the European honey bee, *Apis mellifera* L.

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Addendum

Through the courtesy of Miss K. Omura, we recently received some alcoholed *A. i. cerana* workers from the vicinity of Matsué, Shimane Prefecture. An attempt was made to dissect some specimens to examine the number of ovarioles, and we obtained the following results (Number of individuals in parentheses): Right ovary, 5 (1), 6 (4), 7 (3), 8 (2), 12(1); left ovary, 6 (4), 7 (2), 12 (1), 16 (1), more than 20 (1). Namely, the range of ovariole number fairly coinsides with those shown in the text.

九州から未記録のトビムシ1種

日高輝展・尊田望之

筆者等は去る1958年1月25日，福岡・佐賀県境に横たわる脊振山に冬期採集を試みた．真冬の事で積雪は頂上（1056 m）附近で約 50 cm あり，天候は快晴であつた．脊振山系の板屋峠（655 m）に至る登山路に沿つた積雪上で跳躍するトビムシ多数を採集することが出来た．なお，トビムシは約 500～600 m の高度に亘つて見ることが出来た．

弘前大学の内田一教授に同定を依頼したところ，本種は *Agrenia bidenticulata*(Tullberg) ケントビムシであり，九州から未記録との事であつたので，こゝに記録する次第である．

内田一教授の御教示によれば，本種は元来 boreal species で，北欧，北極圏，シベリア，グリーンランド，北米，日本では従来本州だけに分布し（北は青森県から西南の鳥取県までかなり広い範囲に亘る）積雪上，または融雪の縁辺，雪渓などで得られるとの事である．

末筆ながら御多忙中にも拘わらず快く御同定，御教示下さつた内田一教授に対し厚く御礼申上げる．