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Two New Species of *Myrmica* (Hymenoptera, Formicidae) from Korea

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Two new species of *Myrmica* from Korea are described. *M. koreana* belongs to the *schencki* species-group of *Myrmica* and is most similar to *M. schencki*. It is possibly endemic to the Korean Peninsula. *M. hyungokae* belongs to the *lobicornis*-group and is most similar to *M. jessensis*. It has some characters normally associated with social parasites but it is probably a free-living species. Both new species were clearly separated from their nearest relatives on subjective characters (shape, sculpture etc.) and this was confirmed by discriminant analysis of the morphometrics.

About a third of the 120 palaearctic specific and infra-specific forms of the temperate ant genus *Myrmica* Latreille listed by Bolton (1995), occur in East Asia. The genus is relatively abundant on the Korean peninsula (e.g. Kim and Kim, 1983, Kim, 1996). In the north of the Korean peninsula, *Myrmica* ants can be found at quite low altitudes, and the fauna comprises species that are also found in the adjacent regions of north-east China and Primorsky region of Russia, Sakhalin and Kurilan Islands and the northern islands of Japan. However, South Korea is considerably warmer in summer and the *Myrmica* fauna is more typical of the oriental fauna found in central Japan and parts of eastern and central China. Furthermore, in South Korea *Myrmica* populations are generally restricted to the tops of high mountains which are isolated from each other by areas of hot and dry lowland that are unsuitable for *Myrmica* ants; such isolation can lead to the evolution of locally endemic species.

Only two species of *Myrmica* have been described from Korea: *Myrmica incurvata* Collingwood, 1976, which is very similar to and is probably a synonym of *Myrmica angulinodis* Ruzsky, 1905, was described from North Korea while *Myrmica cadusa* Kim et al., 1997, which was described from South Korea, is very similar to and is probably a synonym of *Myrmica excelsa* Kupyanskaya, 1990. We have found two new species which may be endemic to Korea. Here, we formally describe them and use morphometric analysis to show that they are quite distinct from *Myrmica jessensis* Forel, 1901 and *Myrmica schencki* Emery, 1895, the most similar of the previously known species present in East Asia.

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Materials and Methods

Myrmica ants from among pitfall traps samples taken by B.-J. Kim as part of a myrmecofaunal survey of South Korea, were sorted and identified in preparation for a revision of the genus in Korea. We found 40 worker specimens of two species that belonged to no known taxon (collection details with descriptions); later a further four specimens of one of the species were found among material from North Korea in the collection of Museum and Institute of Zoology P.A.N., Warsaw (MIIZ). A holotype of each species was designated and drawn before depositing in the British Museum Natural History (BMNH). The other paratypes are in the collections of G.W. Elmes (ELMES), B.-J. Kim (KIM), Institute of Zoology of Ukrainian National Academy of Sciences, Kiev (IZK) and in Warsaw (MIIZ).

All samples of both species were measured (14 morphological features) using a graticule accurate to 0.01 mm. These were compared with a similar numbers of *M. jessensis* (15 workers taken at random from 8 Korean, 4 Russian (Primorsky Region) and 1 Japanese colonies) and *M. schencki* (26 workers from 10 Danish, 4 French, 3 Spanish, 3 Irish and 3 Turkish colonies). We follow our previous publications on genus *Myrmica* and use the following abbreviation for morphometrics and indices.

HL : length of head in dorsal view, measured in a straight line from the anterior point of median clypeal margin to mid-point of the occipital margin, HW :

maximum width of head in dorsal view behind the eyes, FW : minimum width of frons between the frontal lobes, FLW : maximum width between external borders of the frontal lobes, SL : maximum straight-line length of antennal scape seen in profile, AL : length of tibia of hind leg, HTL : maximum width of pronotum from above in dorsal view (workers), PNW : maximum width of pronotum from above in dorsal view (workers), PL : maximum length of petiole from above, PPL : maximum length of postpetiole from above, PW : maximum width of petiole from above, PPW : maximum width of postpetiole from above, PH : maximum height of petiole in profile, PPH : maximum height of postpetiole in profile, ESL : maximum length of propodeal spine in profile, ESD : distance between tips of propodeal spine from above. Cephalic : CI = HL / HW, Frontal : FI = FW / HW, Frontal lobe : FLI = FLW / FW, Scape (1) : SI_1 = SL / HL, Scape (2) : SI_2 = SL / HW, Petiole (1) : PI_1 = PL / PH, Petiole (2) : PI_2 = PL / HW, Postpetiole (1) : PPI_1 = PPL / PPH, Postpetiole (2) : PPI_2 = PPH / PPW, Postpetiole (3) : PPI_3 = PPW / PPW, Postpetiole (4) : PPI_4 = PPW / HW, Spine-length : ESLI = ESL / HW, Spine-width : ESDI = ESD / ESL, Hind tibia length : HTI = HTL / HW.

Also, the morphometrics were used to make a Canonical Variate Analysis (CNVA) of the four groups (the two putatively new species, *M. jessensis* and *M. schencki*). For a detailed explanation of the methods see Blackith & Rayment (1971) and for its application to *Myrmica* ants see Elmes (1978) and Elmes & Thomas (1985). In simple terms this method attempts to maximise the between-group to within-group variance ratio by searching for a linear combination of the original morphometrics (discriminant functions or Canonical Variates, CVs) that emphasise differences which exist between the groups while at the same time minimising differences between individuals within the groups. The number of CVs possible are one less than the number of groups, in this case four groups result in three CVs. The method can not discriminate between groups unless real differences exist in the original morphometrics, but the advantage of using CNVA over simple ratios is that differences between many of the original variables are combined in a few CVs which usually have greater overall discriminatory power.

For convenience the CV scores are standardised to have unit average within-group variance and an overall mean of zero. The method assumes that the original measurements are normally distributed and that the within-group variances are homogenous, in which case the within-group CV scores should all have the same spread with confidence limits equal to $\%\Pi^2_{(df\,-\,1)}$. In practise the data rarely confirm exactly to the assumption, therefore following previous studies (Elmes & Thomas, 1985) where illustrations plot two CVs against each other, we calculate the actual confidence limit for each group from the CV scores and plot the confidence ellipse whose major axis lies along the correlation between the two CV scores. The closer the fit of the data to the method assumptions the more the ellipses appear as equal-sized circles.

Results

Myrmica koreana sp. n. (Figs. 1a-d)

Material examined: holotype, worker [K-100 (9)], S. Korea, unknown location, in pitfall traps, leg. B.-J. Kim (BMNH). Paratypes: 13 workers [K-100 (1-8, 9-14)] same series as holotype; 1 worker [K-99 (1)] S. Korea, Gechon-ri, nr. Pyongchang, Pyong chang-gun. In pitfall traps c.1970, leg. B.-J. Kim; 4 workers (1 no gaster) [K-115 (1 [no gaster], 4, 5, 7)] S. Korea, mountains, locality not known, leg. B.-J. Kim; 1 worker [K-122 (1)], S. Korea, mountains, locality not known, leg. B.-J. Kim; 7 workers [K-118 (2, 5, 7-11)], S. Korea, Sunchon City, 300 m. in soil. 2.vii.1982, leg. B.-J. Kim; 4 workers (1 no gaster) Korea, Pyongyang, 21.vii.1959, leg. B. Pisarski & J. Prószyski, Inst. Zool. P.A.N. Warszawa 58/59. (ELMES, BMNH, IZK, MilZ).

Workers: The head is slightly longer than broad (suboval), with strongly convex sides, a straight or slightly convex occipital margin, and very broadly rounded occipital corners; anterior clypeal margin is shallowly but distinctly notched medially. The frons is quite narrow (< 0.30 headwidth); frontal carinae are strongly curved and do not merge with the rugae which surrounded the antennal sockets, generally these rugae are reduced to a trace and are barely visible. The antennal scapes are relatively long and sharply bent at their bases (almost at right angles), with a small vertical lobe; the 3^{rd}-5^{th} funicular joints are about 1.5 times longer than broad.

In profile, the alitrunk dorsum forms a somewhat flattened arch; metalpleural groove very shallow; promesonotal suture indistinct (seen from above); metapleural lobes angulate posterodorsally, but not pointed; propodeal spines are long, straight and sharp (they do not appear broadened at their bases) projecting backwards and upwards at just less than 45° to the horizontal. The petiole is relatively low (height distinctly < length) with a short but distinct peduncle; seen in profile the anterior surface of petiole is distinctly concave, forming a rounded right angle where it meets the dorsal surface, while the posterio-dorsal surface forms a shallow, but somewhat angulate arch. The postpetiole is subglobular, relatively low and wide; in profile its ventral surface slopes backwards and appears almost straight, its posterio-dorsal surfaces form a slightly angulate arch with the apex close to the posterior. The hind and middle tibiae have large pectinate spurs.

The mandibles finely longitudinally rugulose; the frons and clypeus longitudinally rugose, with the central part of clypeus having reduced rugosity; remainder of

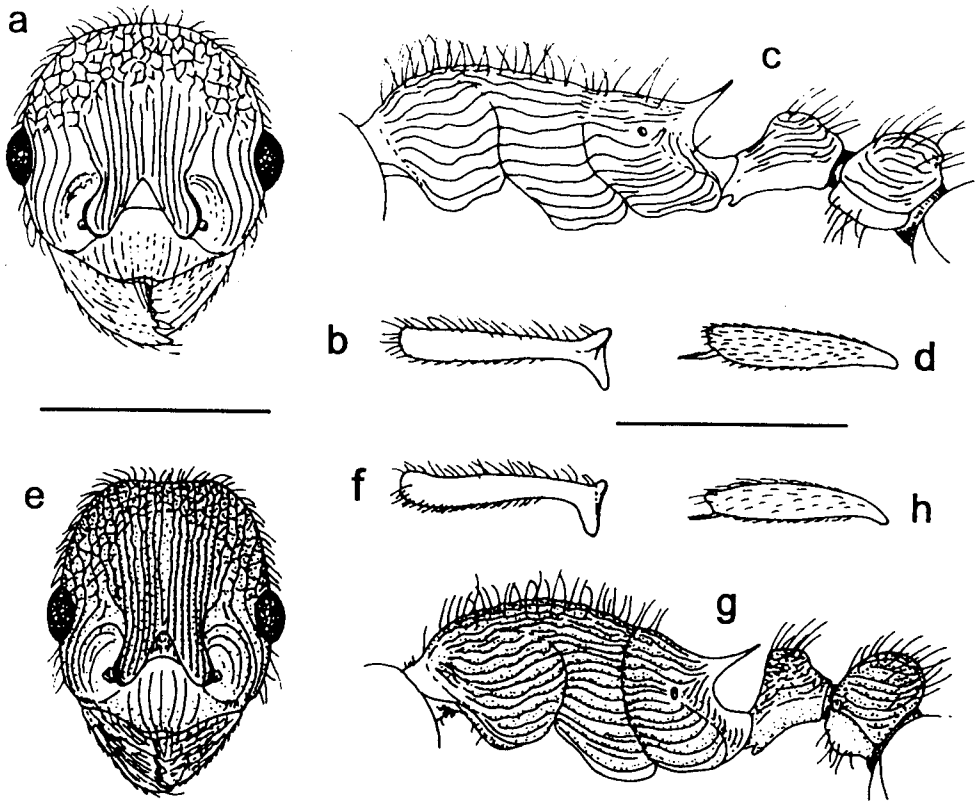

Fig. 1. Details of structure of holotype workers of *Myrmica koreana* sp. n. (a-d) and of *M. hyungokae* sp. n. (e-h). Head, dorsal view (a, e); antennal scape in profile (b, f); alitrunk and waist in profile (c, g) and tibia of hind leg (d, h). Scale bars = 1 mm.

head dorsum coarsely reticulated; surfaces between the rugae are finely punctured but appear more or less shiny; frontal area and clypeus appear smooth and shiny. The alitrunk has coarse, sinuous rugosity on its dorsum and straight longitudinal rugae on its sides; petiole and postpetiole have coarse longitudinal rugae (some straight and some sinuous). The surfaces of the alitrunk and waist finely punctured but appear shiny (like head dorsum); gaster smooth and shiny. The whole body has abundant thin, straight or slightly curved, erect to suberect hairs; those of the occipital and lateral margins of head and scapes being suberect, those of the legs being subdecumbent. The overall colour is yellowish; alitrunk and waist testaceous yellow, and the head and gaster yellowish red.

Etymology: named for Korea where it is probably endemic.

Notes: Females and males are unknown. Little is known on the ecology of *Myrmica koreana* other than it has been caught from baited pitfall traps placed in mixed deciduous forest on mountains.

Based solely on the workers, *Myrmica koreana* appears more similar to the *schencki* species-group (Radchenko, 1994a,c). The closest species are *Myrmica schencki* Emery and *Myrmica lacustris* Ruzsky, 1905 (= *Myrmica deplanata* Ruzsky, 1905). It clearly differs from *M. lacustris* by having a narrower frons (FI 0.29 *v* 0.31-see Seifert, 1988; Radchenko, 1994b); by a larger lobe on the base of antennal scape (Fig. 1b *v* Fig. 1 in Radchenko, 1994b); and by distinctly longer propodeal spines (ESLI) 0.31 *v* 0.20-see Seifert, 1988). *M. lacustris* has not been recorded in East Asia but *M. schencki* is widespread in the Primorsky region of Russia and has been found in very small numbers in ant-collections from North Korea (*unpublished*). *M. koreana* very clearly differs from *M. schencki* by having a much more shallow metanotal groove; by a coarser, more regular sculpture of the alitrunk (Fig. 1c *v* Fig. 5 2 in Radchenko, 1994b); by a wider frons (FI 0.29 *v* 0.24 see Seifert, 1988; Radchenko, 1994b). Also, while the scape lobe is large and distinct it is generally smaller than that of *M. schencki*.

Myrmica hyungokae sp. nov. (Figs. 1 e-h)

Material examined: holotype, worker [K-101 (2)], S. Korea, Mt. Jiri. nr. Gure, Jeonnam prov, Nogodan area - high mountain, c1972, in pitfall trap, leg. B.-J. Kim. (BMNH). Paratypes: 3 workers [K-101 (1, 3, 4)], same series as holotype; 4 workers [K-8 (1-3)], S. Korea, Mt.

Table 1. The morphometrics (mm) for the four *myrmica* species measured

Morphometrics	*Myrmica koreana* (29)*			*M. hyungokae* (14)			*M. jessensis* (15)		*M. schencki* (26)	
	Holotype	Mean	Range	Holotype	Mean	Range	Mean	Range	Mean	Range
HW**	1.02	1.006	0.90 - 1.12	0.97	0.917	0.84 - 0.98	1.011	0.86 - 1.14	1.079	0.94 - 1.22
HL	1.15	1.124	1.02 - 1.24	1.08	1.050	0.98 - 1.09	1.173	1.02 - 1.28	1.181	1.08 - 1.32
FW	0.31	0.296	0.27 - 0.35	0.31	0.298	0.28 - 0.33	0.362	0.30 - 0.41	0.252	0.20 - 0.28
FLW	0.49	0.473	0.43 - 0.54	0.41	0.402	0.38 - 0.44	0.465	0.42 - 0.52	0.415	0.36 - 0.47
SL	0.97	0.954	0.88 - 1.04	0.88	0.849	0.76 - 0.90	0.888	0.76 - 0.98	0.940	0.80 - 1.04
AL	1.71	1.666	1.51 - 1.78	1.50	1.491	1.44 - 1.54	1.605	1.40 - 1.80	1.656	1.50 - 1.84
PH	0.36	0.355	0.32 - 0.38	0.39	0.369	0.33 - 0.40	0.367	1.31 - 0.41	0.373	0.33 - 0.42
PPH	0.43	0.437	0.38 - 0.50	0.48	0.465	0.43 - 0.50	0.478	0.43 - 0.54	0.475	0.41 - 0.54
PW	0.28	0.282	0.25 - 0.31	0.31	0.296	0.26 - 0.32	0.284	0.22 - 0.33	0.310	0.28 - 0.37
PPW	0.43	0.424	0.37 - 0.47	0.47	0.452	0.42 - 0.48	0.457	0.39 - 0.59	0.479	0.43 - 0.56
PL	0.46	0.467	0.39 - 0.54	0.39	0.395	0.37 - 0.43	0.451	0.40 - 0.52	0.483	0.40 - 0.57
PPL	0.39	0.366	0.29 - 0.44	0.38	0.359	0.30 - 0.39	0.339	0.28 - 0.40	0.387	0.33 - 0.48
ESL	0.29	0.315	0.26 - 0.36	0.32	0.311	0.28 - 0.34	0.296	0.22 - 0.37	0.360	0.30 - 0.41
ESD	0.38	0.409	0.35 - 0.47	0.48	0.463	0.41 - 0.52	0.402	0.33 - 0.48	0.491	0.40 - 0.61
PNW	0.71	0.710	0.63 - 0.82	0.71	0.688	0.64 - 0.74	0.716	0.62 - 0.80	0.750	0.66 - 0.84
HTL	0.91	0.932	0.84 - 1.12	0.81	0.787	0.74 - 0.83	0.872	0.76 - 1.00	0.865	0.76 - 0.96

* The number of workers measured. ** See text for measurement abbreviations.

Jiri, nr. Gure, 7-8-1972, in pitfall trap, leg. B.-J. Kim; 4 workers [K-9 (1-4)], S. Korea, Mt. Jiri, nr. Gure, 19-8-1972, in pitfall trap, leg. B.-J. Kim; 3 workers [K-120 (2-4)], S. Korea, nr. Tokyusan 1200m., 21.viii.1994, leg. B.-J. Kim (ELMES, BMNH, IZK, KIM).

Workers: The head is slightly longer than broad, with feebly convex or even subparallel sides, slightly concave occipital margin, and rounded occipital corners; anterior clypeal margin shallowly but distinctly notched medially; frons narrow (0.32 the width of the head), the frontal carinae are strongly curved but do not merge with the rugae which surrounded the antennal sockets. The antennal scapes are relatively short and sharply bent at their bases (almost at right angle), with small vertical tooth-like lobes. The 3rd-5th funicular joints are relatively short (length < 1.5 times breadth).

In profile, the alitrunk dorsum forms a more or less regular but somewhat flattened arch; the metanotal groove is very shallow (almost indistinct); the promesonotal suture is indistinct (seen from above); metapleural lobes angulate posterodorsally, but not pointed; propodeal spines are relatively long straight and sharp, with moderately broad bases, projecting backwards and upwards at an angle < 45° to horizontal. The petiole is relatively short and high, with a very short and thick peduncle; seen in profile the petiolar node is distinctly truncate (appearing subsquare), the dorsal surface gradually slopes backwards and the anterior and posterior surfaces appear almost vertical. The postpetiole is relatively massive, wide and distinctly higher than long; in profile the dorsum forms a broadly rounded arch with its apex posterior of the mid point, and the ventral surface is distinctly prominent. Tibial spurs are present and well developed on middle and hind tibiae but they are only feebly pectinate.

The anterior and central parts of the frons and clypeus are longitudinally rugose; remainder of the head dorsum is coarsely reticulate; frontal area longitudinally striated; mandibles finely longitudinally rugulose. Surfaces between rugae are finely but distinctly punctured, appearing dull; clypeus is more or less shiny. Sides of alitrunk have coarse longitudinal sinuous rugae and dorsum coarsely reticulate; entire petiole coarsely reticulate; postpetiole longitudinally rugose. Surfaces between the rugae on the alitrunk and waist are finely punctured (like the head dorsum); gaster is smooth and shiny. Occipital and lateral margins of head and entire alitrunk with abundant thick, straight, erect to suberect hairs; legs with numerous subdecumbent hairs, scapes with suberect hairs. General colour brownish-red; sides of alitrunk testaceous red and the appendages dark yellow.

Etymology: named for Kim Hyungok, wife of one of the authors.

Notes: Females and males are unknown. Little is known on the ecology of *Myrmica hyungokae* other than it has been caught from baited pitfall traps placed in mixed deciduous forest on mountains. Based on worker characters we place *M. hyungokae* in the *lobicornis* species-group (Radchenko, 1994a, d). Although it probably is closely related to *M. jessensis* it is well separated from that species (see morphometric analysis). We distinguished it from *M. jessensis* by its very shallow mesopropodeal furrow (Fig. 1g); by its narrower frons (FI 0.32 *v* 0.36); by its wide postpetiole (PPI4 0.49 *v* 0.45), with its prominent ventrally extended process (Fig. 1g; by the reduced pectination on the spurs of the middle and hind tibiae (Fig. 1h). The last two are characteristics of socially parasitic *Myrmica* species. Workers of social parasites have been described previously (e.g. *Myrmica hirsuta* Elmes; see Elmes, 1994) so that *M. hyungokae* could be a social parasite (*M. jessensis* would be the main candidate for the host species). However, we think this is unlikely because free living species with similar "parasitic" characters have been found among the NE Asian fauna (e.g. *Myrmica arnoldii* Dlussky, 1963 and *Myrmica luteola* Kupyanskaya, 1990).

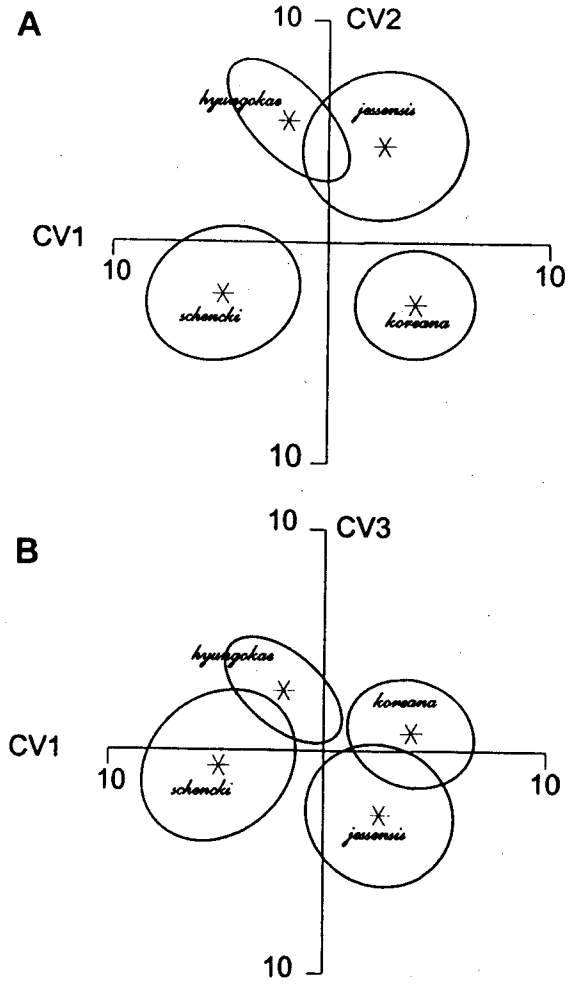

Fig. 2. The 99% confidence elipses around the mean canonical variate scores for the four species. A, CV1 plotted against CV2 clearly separates *M. koreana* from the other species. B, CV3 clearly discriminates between *M. hyungokae* and *M. jessensis*. For a more detailed interpretation see the text.

Morphometric Analysis

Canonical variate analysis easily discriminates between all four species (Fig. 2). The first canonical variate (CV1 which explains 48% of the total variation) and the second (CV2-42% of variation) discriminate between *M. schencki*, *M. koreana* and *M. jessensis* (Fig. 2a). Although *M. hyungokae* is not entirely separated from *M. jessensis* by these first two discriminant functions the third (CV3 accounting for the remaining 10% of the variation) clearly discriminates them (Fig. 2b). All of the original measurements contributed to the discrimination except for PL, PPL and PH which could be dropped without any loss in the power of the discrimination. This analysis confirms that the initial "recognition" of the two new species based upon subjective characters such as sculpture, petiole shape and scape shape is reflected by a clear discrimination based on non-subjective morphometrics.

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Table 2. The indices for the four *myrmica* species measured

Indice	*Myrmica koreana* (29)*			*M. hyungokae* (14)			*M. jessensis* (15)		*M. schencki* (26)	
	Holotype	Mean	Range	Holotype	Mean	Range	Mean	Range	Mean	Range
CI**	1.12	1.12	1.08 - 1.17	1.12	1.15	1.11 - 1.18	1.16	1.11 - 1.22	1.10	1.05 - 1.16
FI	0.30	0.29	0.27 - 0.31	0.32	0.32	0.31 - 0.34	0.36	0.32 - 0.39	0.23	0.20 - 0.26
FLI	1.59	1.60	1.50 - 1.68	1.32	1.35	1.29 - 1.42	1.29	1.18 - 1.40	1.66	1.46 - 1.85
SI1	0.84	0.85	0.79 - 0.90	0.81	0.81	0.78 - 0.83	0.76	0.73 - 0.80	0.80	0.70 - 0.85
SI2	0.95	0.95	0.87 - 1.00	0.91	0.93	0.90 - 0.96	0.88	0.83 - 0.94	0.87	0.80 - 0.92
PI1	1.27	1.32	1.19 - 1.49	1.02	1.07	1.02 - 1.23	1.23	1.10 - 1.47	1.30	1.13 - 1.53
PI2	0.45	0.46	0.44 - 0.52	0.41	0.43	0.41 - 0.51	0.45	0.41 - 0.50	0.45	0.39 - 0.52
PPI1	0.89	0.84	0.61 - 0.93	0.79	0.77	0.67 - 0.84	0.71	0.56 - 0.80	0.82	0.67 - 1.00
PPI2	1.00	1.03	0.98 - 1.12	1.01	1.03	0.93 - 1.07	1.05	0.92 - 1.11	0.99	0.93 - 1.07
PPI3	1.55	1.50	1.43 - 1.61	1.52	1.53	1.43 - 1.63	1.61	1.45 - 1.79	1.55	1.45 - 1.67
PPI4	0.42	0.42	0.40 - 0.45	0.49	0.49	0.48 - 0.52	0.45	0.42 - 0.52	0.44	0.42 - 0.48
ESLI	0.29	0.31	0.27 - 0.34	0.33	0.34	0.31 - 0.38	0.29	0.23 - 0.36	0.33	0.29 - 0.38
ESDI	1.29	1.30	1.13 - 1.69	1.47	1.49	1.28 - 1.74	1.37	1.17 - 1.64	1.37	1.16 - 1.61
HTI	0.49	0.93	0.88 - 1.00	0.84	0.86	0.83 - 0.90	0.86	0.80 - 0.90	0.80	0.74 - 0.87

* The number of workers measured are given in parenthesis. ** See text for Indice code.

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